FAST LOAD FLOW TECHNIQUES OF LARGE SCALE SYSTEMS

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CERTIFICATE

Certified that this work 'FAST LOAD FLOW TECHNIQUES OF LARGE SCALE SYSTEMS' by Shri Pankaj Gupta has been carried out under my supervision and has not been submitted elsewhere for a degree.

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ABSTRACT

Exhaustive studies have been conducted in the field of load flow analysis. The results of these studies have pointed out the advantages of the fast converging methods like Newton-Raphson especially in polar coordinates and Fast Decoupled method . The former method has the disadvantage of large memory requirement and greater computation time. These methods (in particular Newton-Raphson) become a practical tool only when sparsity of the coefficient matrix and bus admittance matrix are exploited. The use of ordered elimination reduces the computation time further.

In this thesis, programs have been developed to perform LF studies by all the three methods such as, NR , D.C. and FD. Sparsity ordered eliminations are the key features of the program. A comparative study of these three methods with reference to computation time and memory requirements is also given.

CHAPTER 1

INTRODUCTION

The modern trend is to form a grid system of all the available energy sources i.e. towards interconnecting all types of generating stations. This provides the greatest advantage of meeting the load supply demands economically at all times. The power supply undertakings must keep pace with the load growth. In addition to the above, care must be taken so as not to overload the interconnecting systems resulting into their instability.

Load flow analysis is very important when new components or additions to existing ones are considered. With proper and accurate load flow studies, the interruption of power can be minimised. Load flow calculations are necessary at the initial stage for the purpose of planning, operation and control. It provides voltage magnitude and phase angle at each bus and power flows including line losses in each element of the power system network. Apart from determining the steady state operating conditions of a power system network for the purpose of planning, operation and control, load flow calculations also provide initial conditions for transient stability studies.

Prior to the advent of digital computer, load flow studies were performed on A.C. calculating boards i.e. network

analysers. A calculating board is a single phase scaled down model of a balanced three phase system. The board being made up of a number of elements viz. resistances, inductances and capacitances, all of which are adjustable, along with a number of sources and measuring instruments. Initial adjustments in this case usually take a lot of time since each adjustment at any bus affects values of pertinent quantities at other buses. In addition to this, considerable amount of time is lost in recording observations.

The appearance of the digital computers revolutionized the whole concept of load flow calculations. Mathematical model (i.e. equations) which were once thought to be cumbersome and of purely theoretical interest became practically feasible. The ease with which computers can handle arithmetic operations gave a boost to the numerical methods. The mathematical model for the purpose of load flow studies is a set of non-linear algebraic equations. The non linearity of the system of equations defies an exact analytical solution and one must resort to some iterative techniques which will render a sufficiently accurate numerical solution. There is no dearth of numerical techniques available, only the enormous computational effort is a deterrent, but with the coming of the digital computer, it is no longer a stumbling block, for now the problem is to develop an algorithm for solving these equations on the computer.

The first practical methods to solve these power system network equations on a digital computer, appeared in literature in 1956 [1,2]. These methods (one of the methods was the gauss-seidel technique) required minimum storage and hence were well suited to the first generation computers. However these methods were slow in convergence and thus not very well suited to handle large systems. Any method which has to handle a large system must possess the following two key features.

1. Nominal storage requirements
2. Reliable and fast in convergence.

The Newton-Raphson method's quadratic convergence property was highlighted around the same time [3,4] but was found to be computationally uncompetitive. The application of sparsity programmed ordered elimination by Tinmy and Walker to the Newton-Raphson method reduced the storage requirement and also optimized the computation time to such an extent that Newton-Raphson method gained popularity over and above other methods [5], and has now come to be widely regarded as the general purpose load flow approach [6]. The decoupled and fast decoupled load flow techniques are modifications of the Newton-Raphson method which exploit the loose physical interaction between MW and MVAR flows in a power system. Storage and computation time are further minimized in the above mentioned methods, without appreciable loss in accuracy.

Present day power systems are large and complex because of greater interconnection. To analyse such a large scale system on a digital computer with limited memory application of sparsity oriented ordered elimination techniques are needed.

Keeping the above factors in view, programs are developed for the three methods viz. Newton-Raphson, Decoupled and Fast Decoupled. These programs have been tested for a 100 bus 128 line system of UPSEB. Programs are capable of handling a larger system; data storage requirements of the large system are the limiting factors which dictate system size that can be simulated on a particular digital computer. Although the use of magnetic tapes can overcome this problem to some extent, one has to pay in terms of speed. The main features of the programs developed in this thesis are:

1. User oriented input/output format
2. Storage of only non-zero elements of Y_{bus}
3. Storage of only non-zero elements of Jacobian
4. Ordered elimination of the Jacobian equation

The chapter-wise summary of the work covered in this thesis is given as follows.

Chapter 2 is devoted to the theoretical aspects of the methods used viz. Newton-Raphson, Decoupled and the Fast Decoupled method. A brief account of each method and their relative merits are also discussed in this chapter.

Chapter 3 deals with sparsity . ordered elimination. A general description of the technique and in specific, its application to power system problem has been given.

Chapter 4 deals with the case study of the following systems

14 bus 20 lines IEEE system

57 bus 80 lines IEEE system

and 100 bus 128 lines UPSEB system.

The advantage of sparsity ordered elimination are elaborated by comparasion of results for the three systems in relation to memory requirements and computer time. Detailed flow chart for all the methods used as well as results etc. are given.

Chapter 5 concludes with the specific findings in this thesis along with future scope of the work.

CHAPTER 2

LOAD FLOW TECHNIQUES

2.1 INTRODUCTION:

This chapter deals with the currently favoured methods for load flow studies. A literature survey will reveal a host of algorithms which have been suggested from time to time to solve this problem of load flow analysis. An excellent review of the major portion of work done in this field has been given in [7]. In general it is difficult to point out the best method for a particular application. The relative properties and performances of different load flow methods can be influenced substantially by the types and size of the problems to be handled and also by the computing facilities available. Any final choise is invariably a compromise between the various criteria of goodness by which the load flow methods are to be compared with each other. Every such criteria is directly or indirectly associated with financial cost. This chapter spells out the details of the load flow problem and the numerical techniques for its solution.

2.2 LOAD FLOW STUDIES:

The objective of the load flow study is to determine the phase angle and reactive power on each P-V bus and the phase angle and voltage magnitude at each P-Q bus subject to the constraints on the real and reactive power at

P-Q buses and the real power and voltage magnitude at the P-V buses. Based upon this it is possible to classify the buses into three categories.

2.3 BUS CATEGORIZATION:

The buses are categorized depending on the quantity specified at the bus

a) Load or a P-Q bus

b) Voltage controlled or a P-V bus

c) Slack or swing bus

a) Load or a P-Q bus: For this type of a bus, we know a priori P_{L_i} and Q_{L_i} and specify P_{G_i} and Q_{G_i}. In effect we thus specify the bus injections P_i and Q_i. Solution of the load flow equations will render $|V_i|$ and θ_i. A load bus which due to its lack of generating equipment, is characterized by zero P_{G_i} and Q_{G_i} evidently falls in this category.

b) P-V or a voltage controlled bus: For this type of a bus we know a priori P_{L_i} and Q_{L_i} and specify $|V_i|$ and P_{G_i}. In effect, we thus specify the bus powers P_i. Solution of the load flow equations render Q_i (and hence Q_{G_i}) and θ_i. This is called a voltage controlled bus because its voltage can be controlled.

c) Slack or swing bus: This is the reference bus where the voltage magnitude and phase angle are specified. One of the generator with the maximum real power capabilities must be

selected as the swing bus to provide for the additional real and reactive power to supply line losses because these are unknown till the final load flow solution is obtained. The variables of interest at this bus are the real and reactive power.

Assuming balanced 3-phase conditions, which is usually done for the purpose of load flow studies, the transmission system can be represented by its positive sequence network. The nodal admittance matrix can be expressed as follows

$$\underset{(n\times 1)}{I_{BUS}} = \underset{(n\times n)}{Y_{BUS}} \quad \underset{(n\times 1)}{V_{BUS}} \tag{2.1}$$

The above equation can be written in the following form for a P^{th} node.

$$I_p = \sum_{q=1}^{n} Y_{pq} V_q \tag{2.2}$$

$$p = 1,2,\ldots,n$$

This equation simply states that the currents at any node or bus is the algebraic sum of all the currents entering or leaving the node. The power at any bus is calculated by the $V_p I_p^*$ product.

$$V_p I_p^* = V_p \sum_{q=1}^{n} Y_{pq}^* V_q^* \tag{2.3}$$

separating equation (2.3) into the real and imaginary parts gives us the expressions for real and reactive powers i.e.

$$P_p = \text{REAL} \; [V_p \sum_{q=1}^{n} Y^*_{pq} V^*_q] \tag{2.4}$$

$$Q_p = \text{IMAG} \; [V_p \sum_{q=1}^{n} Y^*_{pq} V^*_q] \tag{2.5}$$

$$p = 1,2,\ldots n.$$

With the following substitutions for Y_{pq}, V_p and V_q

$$Y_{pq} = G_{pq} + jB_{pq}$$

$$V_p = |V_p| \; (\cos \Theta_p + j \text{ sine } \Theta_p)$$

$$V_q = |V_q| \; (\cos \Theta_q + j \text{ sine } \Theta_q)$$

equations (2.4) and (2.5) become

$$P_p = |V_p| \sum_{q=1}^{n} ((G_{pq} \cos \Theta_{pq} + B_{pq} \text{ sine } \Theta_{pq})|V_q|) \tag{2.6}$$

$$Q_p = |V_p| \sum_{q=1}^{n} ((G_{pq} \text{ sine } \Theta_{pq} - B_{pq} \cos \Theta_{pq})|V_q|) \tag{2.7}$$

Let us examine the number of knowns and unknowns at the three type of buses.

suppose total number of buses	=	N
slack bus	=	1
Number of P-Q buses	=	M
Number of P-V buses	=	N-M-1

If V and θ are known at all the buses we can find out P and Q at all buses using equations (2.6) and (2.7) i.e. V and θ are the state variables.

Total number of possible unknowns $= 2N$

As voltages at all P-V buses are known and also at slack bus V is assumed 1.0 p.u. and angle $\theta_s = 0^o$.

$$\text{Number of knowns} = N-M-1+2$$
$$= N-M+1$$
$$\text{Number of unknowns} = 2N-(N-M+1)$$
$$= N+M-1$$

Hence (N+M-1) equations are needed to solve for the unknowns. For each load bus P and Q are known so we can write two equations at each P-Q bus. Also P is known at each P-V bus so one equation for P can be written for each P-V bus.

$$\text{Number of equations for (N-M-1) P-V buses} = N-M-1$$
$$\text{Number of equations for M P-Q buses} = 2M$$
$$\text{Total number of equations} = 2M+N-M-1$$
$$= N+M-1$$

Thus the number of equations is equal to the number of unknowns [Note this has been possible, only if θ_{pq} i.e. $(\theta_p - \theta_q)$ is treated as one unknown by taking one of the buses as reference].

Bus constraint equations are

$$\Delta P_p = P_p^{sp} - P_p^{cal} \tag{2.9}$$

$$\Delta Q_p = Q_p^{sp} - Q_p^{cal} \tag{2.10}$$

where superscript 'sp' and 'cal' stand for specified and calculated respectively. P_p^{cal} and Q_p^{cal} are obtained from the equations (2.6) and (2.7). As can be seen by the appearence of cos Θ_{pq} and sine Θ_{pq} terms in the expressions for P_p^{cal} and Q_p^{cal} , it is a system of non-linear equations and one has to resort to numerical techniques to obtain a solution. The solution of these equations for V's and Θ's is the load flow problem.

2.4 NEWTON RAPHSON METHOD:

When there is no mismatch between the specified and calculated powers equations (2.9) and (2.10) [in matrix notation] become

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = 0 \tag{2.11}$$

Applying Newton-Raphson method we have

$$
\left[\begin{array}{c} \Delta P_1 \\ \Delta P_2 \\ \Delta P_3 \\ \vdots \\ \Delta P_{N-1} \\ \hline \Delta Q_1 \\ \Delta Q_2 \\ \vdots \\ \Delta Q_M \end{array}\right]
=
\left[\begin{array}{cccc|cccc}
\frac{\partial \Delta P_1}{\partial \theta_1} & \frac{\partial \Delta P_1}{\partial \theta_2} & \cdots & \frac{\partial \Delta P_1}{\partial \theta_{N-1}} & \frac{\partial \Delta P_1}{\partial V_1}|V_1| & \frac{\partial \Delta P_1}{\partial V_2}|V2| & \cdots & \frac{\partial \Delta P_1}{\partial V_M}|V_M| \\
\frac{\partial \Delta P_2}{\partial \theta_1} & \frac{\partial \Delta P_2}{\partial \theta_2} & \cdots & \frac{\partial \Delta P_2}{\partial \theta_{N-1}} & \frac{\partial \Delta P_2}{\partial V_1}|V_1| & \frac{\partial \Delta P_2}{\partial V_2}|V_2| & \cdots & \frac{\partial \Delta P_2}{\partial V_M}|V_M| \\
\cdots\cdots & & \cdots & & \cdots\cdots & & \cdots & \\
\cdots\cdots & & \cdots & & \cdots\cdots & & \cdots & \\
\frac{\partial \Delta P_{N-1}}{\partial \theta_1} & \frac{\partial \Delta P_{N-1}}{\partial \theta_2} & \cdots & \frac{\partial \Delta P_{N-1}}{\partial \theta_{N-1}} & \frac{\partial \Delta P_{N-1}}{\partial V_1}|V_1| & \frac{\partial \Delta P_{N-1}}{\partial V_2}|V_2| & \cdots & \frac{\partial \Delta P_{N-1}}{\partial V_M}|V_M| \\
\hline
\frac{\partial \Delta Q_1}{\partial \theta_1} & \frac{\partial \Delta Q_1}{\partial \theta_2} & \cdots & \frac{\partial \Delta Q_1}{\partial \theta_{N-1}} & \frac{\partial \Delta Q_1}{\partial V_1}|V_1| & \frac{\partial \Delta Q_1}{\partial V_2}|V_2| & \cdots & \frac{\partial \Delta Q_1}{\partial V_M}|V_M| \\
\frac{\partial \Delta Q_2}{\partial \theta_1} & \frac{\partial \Delta Q_2}{\partial \theta_2} & \cdots & \frac{\partial \Delta Q_2}{\partial \theta_{N-1}} & \frac{\partial \Delta Q_2}{\partial V_1}|V_1| & \frac{\partial \Delta Q_2}{\partial V_2}|V_2| & \cdots & \frac{\partial \Delta Q_2}{\partial V_M}|V_M| \\
\cdots & & \cdots & & & \cdots & \cdots & \\
\cdots & & \cdots & & & \cdots & \cdots & \\
\frac{\partial \Delta Q_M}{\partial \theta_1} & \frac{\partial \Delta Q_M}{\partial \theta_2} & \cdots & \frac{\partial \Delta Q_M}{\partial \theta_{N-1}} & \frac{\partial \Delta Q_M}{\partial V_1}|V_1| & \frac{\partial \Delta Q_M}{\partial V_2}|V_2| & \cdots & \frac{\partial \Delta Q_M}{\partial V_M}|V_M|
\end{array}\right]
\left[\begin{array}{c} \Delta \theta_1 \\ \Delta \theta_2 \\ \Delta \theta_3 \\ \vdots \\ \Delta \theta_{N-1} \\ \hline \frac{\Delta V_1}{|V_1|} \\ \frac{\Delta V_2}{|V_2|} \\ \vdots \\ \frac{\Delta V_M}{|V_M|} \end{array}\right]
\qquad (2.12)
$$

In short the above can be written in the form

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} H & N \\ M & L \end{bmatrix} \begin{bmatrix} \Delta \theta \\ \frac{\Delta V}{|V|} \end{bmatrix} \tag{2.13}$$

where

$\begin{bmatrix} H & N \\ M & L \end{bmatrix}$ is called the Jacobian matrix

H — Partial derivatives of P w.r.t. θ's

L — Partial derivatives of Q w.r.t. V's

N — Partial derivatives of P w.r.t. V's

M — Partial derivatives of Q w.r.t. θ's

The ΔV's are divided by $|V|$ and corresponding elements of Jacobian are multiplied by 'V' to bring about a symmetry in the elements of the Jacobian.

It can be shown that

for $p \neq q$

$$H_{pq} = L_{pq} = |V_p|\ |V_q|\ (G_{pq} \text{ sine } \theta_{pq} - B_{pq} \cos \theta_{pq}) \tag{2.14}$$

$$N_{pq} = -M_{pq} = |V_p|\ |V_q|\ (G_{pq} \cos \theta_{pq} + B_{pq} \text{ sine } \theta_{pq}) \tag{2.15}$$

For p = q we have

$$H_{pp} = -Q_p - B_{pp}\ |V_p|^2 \tag{2.16}$$

$$L_{pp} = Q_p - B_{pp}\ |V_p|^2 \tag{2.17}$$

$$N_{pp} = P_p + G_{pp} |V_p|^2 \tag{2.18}$$

$$M_{pp} = P_p - G_{pp} |V_p|^2 \tag{2.19}$$

Where P_p and Q_p are calculated from equations (2.6) and (2.7).

The solution of equation (2.13) gives us the $\Delta\theta$'s and Δ V's which are used to update earlier estimates of θ's and V's and the process is repeated till the mismatch Δ P and Δ Q become less than a pre-assigned tolerance value ϵ. When this is achieved, the iterative process is stopped as the desired accuracy has been obtained.

2.5 STEPS FOR THE NEWTON-RAPHSON ITERATIVE SCHEME:

1. If nothing is available regarding the actual value of variables at the buses assume a flat start, assign V at all buses equal to slack bus voltage and angles equal to slack bus angle i.e. zero. Set iteration count 'K' to one.

2. Calculate P^{cal} and Q^{cal} (using equation (2.6) and (2.7)) with values of V's and θ's as in step (1).

3. Calculate power mismatch at all buses using equation (2.9) and (2.10).

4. Test for convergence by checking power mismatch. If ΔP's and ΔQ's at all buses are less than a pre-defined value ϵ, we jump out of the iterative loop and go to step (10).

5. Check if the number of iterations has exceeded the predefined value 'ITMAX' (say), if it has exceeded go to step (12).

6. Calculate the elements of the Jacobian using equations (2.14)through (2.19).

7. Solve equation (2.13) for $\Delta\theta$'s and $\frac{\Delta V}{|V|}$'s using one of the direct methods of solution (e.g. Gaussian elimination)

8. Update the voltages and angles at all the buses using the correction factors obtained in step (7). Increment iteration count by '1'

$$|V|^{K+1} = |V|^K + \left|\frac{\Delta V}{V}\right|^K |V| \qquad (2.20)$$

$$\theta^{K+1} = \theta^K + \Delta\theta^K \qquad (2.21)$$

9. With the voltages and angles as given equations (2.20) and (2.21) start the $(K+1)^{th}$ iteration i.e. go to step (2).

10. Using the latest voltage and estimates,calculate slack bus power, line flows and line losses.

11. Go to Step 13 .

12. Convergence not obtained in 'K' iterations.

13. Convergence obtained in 'K' iterations. Print bus status, line flows, line losses.

The main disadvantage of this method is that the storage requirements and computation work involved is enormous. For a 'N' bus system with 'M' P-Q buses the order of Jacobian is (N+M-1). Thus for a typical 100 bus problem with 19 P-V buses including slack bus, which has been carried out in this thesis, we require 32.4 K of computer memory for storing the Jacobian matrix. Storage of data, bus admittance matrix etc. are over and above this. Bus admittance matrix for a 100 bus system will contribute towards a storage requirement of 10K. Thus Jacobian and bus admittance matrix together take the major portion of total storage requirements for any problem. With full storage schemes the solution is limited to small problems because of memory restrictions. The Newton-Raphson method together with sparsity and ordered elimination technique [5] is a powerful tool for obtaining load flow solution, as it optimizes memory requirement as well as computation time. The number of iterations required for solution is virtually independent of problem size. This is strictly true for programs without additional features like automatic tap adjustment of a transformer, Q limit checks etc. which may require additional iterations. A program adjusted for Q limits may take an additional two or more iterations.

2.6 DECOUPLED METHOD:

In all the decoupled methods the load flow equations have been derived from the Newton-Raphson formulation in polar coordinates to reduce memory requirement and computational

efforts. These methods are based on neglecting the coupling terms M and N of the Jacobian matrix in the Newton-Raphson method, on the assumption that the coupling between real bus power versus bus voltage magnitude and reactive power versus bus voltage angle is relatively weak. Any such approximations to the Jacobian inevitably sacrifices the true quadratic convergence property, but compensating computational benefits can accrue. Based upon these assumptions equation (2.13) reduces to two sets of independent equations for P's and Q's.

$$[\Delta P] = H\,[\Delta Q] \tag{2.22}$$

$$[\Delta Q] = L\,\left[\frac{\Delta V}{|V|}\right] \tag{2.23}$$

Equations (2.22) and (2.23) are formulated and solved successively. The latest values of θ are used to solve for V. The decoupled method converges as reliably as the formal Newton-Raphson Method, although it takes more number of iterations to achieve accuracies compatable to the Newton's method. This however is not necessary as convergence to practical accuracies takes more or less the same number of iterations. The saving in terms of memory requirements is nearly 75% for Jacobian element storage although overall saving of the memory is only of the order of 40-50%. The computation time per iteration is also 10-20% less than Newton-Raphson Method.

2.7 FAST DECOUPLED METHOD:

The decoupled method can be further simplified without appreciable loss of accuracy [7,8].In practical power system the following assumptions hold good.

1. θ_{pq} is small .
2. G_{pq} sine $\theta_{pq} << B_{pq}$.
3. $Q_p << B_{pp} |V|^2$.

Applying these assumptions to equations (2.22) and (2.23) [reproduced below].

$$[\Delta P] = H [\Delta\theta]$$

$$[\Delta Q] = L [\frac{\Delta V}{|V|}]$$

We have

$$[\Delta P] = [V B'V]][\Delta\theta] \qquad (2.24)$$

$$[\Delta Q] = [V B''V] [\frac{\Delta V}{|V|}] \qquad (2.25)$$

The elements of the matrix B' and B'' are strictly elements of [-B]. The decoupling process is given a final shape by.

(a) Omitting from [B'] the representation of those network elements that predominantly affect MVAR flows i.e. shunt reactances and off nominal in phase taps.

(b) Omitting from [B''] the angle shifting effects of phase elements.

(c) While calculating for P^{th} bus taking the left hand 'V' terms (for P^{th} bus) in equations (2.24) and (2.25) on to the left hand side of the equations and then in equation (2.24) removing the influence of MVAR flows on the calculations of $\Delta\theta$ by setting all right hand 'V' terms to 1 p.u.

With these assumptions the relevant equations for Fast-Decoupled load flow are

$$\left[\frac{\Delta P}{|V|}\right] = [B'] \, [\Delta \theta] \tag{2.26}$$

$$\left[\frac{\Delta Q}{|V|}\right] = [B''] \, [\Delta V] \tag{2.27}$$

This method though not possessing the true quadratic convergence of the Newton-Raphson method, converges very fast as the time per iteration is very less. It is as reliable as the Newton-Raphson method within the acceptable limits of accuracy. Adjusted solutions, to incorporate all other additional features, in this case, will take more number of iterations but since time per iteration is very less compared to Newton-Raphson method the overall computation time is not affected significantly.

In this chapter we have outlined the various methods of current interest. The methods in themselves are not new but form a powerful tool when sparsity of the Jacobian matrix is exploited. Implemented as such, they may not be able to handle systems of 500 bus or more (especially Newton-Raphson method) whereas using sparsity, we can handle system sizes of 1000 buses and above with little difficulty.

CHAPTER 3

SPARSITY AND OPTIMAL ORDERING

3.1 INTRODUCTION:

The sparsity occurs in some form in most of the physical systems such as communication network, current theory, family trees, organization structure and sociograms. Let a physical system be described by a set of 'n' algebraic linear equations of the form

$$[A]\ x = y \tag{3.1}$$

The problem is to determine the solution vector x by Gaussian elimination method such that the computational efforts and hence, the time of computation i.e. the cost is minimized. Following Von Neuman, the number of multiplication required to obtain solution is counted as a measure of computing time. Therefore if only the number of multiplication is to be counted, a reduced matrix 'M' of the coefficient matrix A [Eqn. 3.1]. whose elements are defined as

$$\begin{aligned} m_{ij} &= 1 \quad \text{if } m_{ij} \neq 0 \\ &= 0 \quad \text{if } m_{ij} = 0 \end{aligned} \tag{3.2}$$

contains all the required information for solving the problem.

Let the number of multiplication to process the i^{th} row be m_i and therefore, for the entire system, the total number of multiplication

$$\emptyset = \sum_{i=1}^{n} m_i \tag{3.3}$$

where n is the number of equations i.e. order of the system.

3.2 FUNCTIONAL EQUATIONS:

Optimal elimination is actually a topological problem which can be formulated using notation from graph theory. Some systems such as electrical networks may be thought of being their own graph, thus a picture of one of these systems with slight modification could serve as its own graph inspite of the fact that there may be more than one scaler quantity associated with each node, other systems such as those arise from difference equations may have no direct graph. For these systems, the following procedure is adopted to construct its graph. With each equation in the coefficient matrix 'A' (eqn. 3.1), there is associated a node in the system graph and with each non-zero term,

$$a_{ij} \quad \text{for } i = 1, \ldots n \qquad j = 1, \ldots n \tag{3.4}$$

there is associated an undirected branch between the ith and the jth node.

The system graph will be referred to as 'G'; during the elimination process it is modified, just as the rows of the coefficient matrix 'A' are modified. Let G^i is a graph obtained by eliminating the ith node from system graph G

[i.e. processing ith row of the corresponding coefficient matrix 'A']. Let W(G) be defined to be the number of multiplication required to solve optimally the system [i.e. [A]x = y] whose graph is 'G' and let (i) be one plus the degree of i^{th} node in the graph 'G'. From this, it is clear, that, W(G) is a minimum value of $\emptyset$ and e_i is the number of multiplications required to eliminate ith row from the given system whose graph is G. Then,

$$W(G) = \text{Min}\ \emptyset\ [\epsilon_i] \tag{3.5}$$

$$W(G) = \text{Min}\ [e_i + W(G^i)\ ] \tag{3.6}$$

where ϵ_i is the permutation of ordering.

Bellman uses the term 'policy' to describe a specific permutation i.e. a certain policy results in a permutation for which it is then possible to evaluate the number of multiplications or work. The optimal policy corresponds to the minimum work.

Following Bellman, it is possible to choose any initial policy i.e. method of ordering the nodes i.e. equations or rows of corresponding coefficient matrix and proceed iteratively to obtain the solution of the above equations i.e. eqn. (3.6) whose solution is unique even though the optimal policy may not be unique.

Let $W_o[G]$ be the number of multiplications needed using initial policy. Then we have from the equation (3.6)

$$W_N[G] = \min_i \; [e_i + W_{N-1}[G^i]] \qquad N = 1,\ldots n \tag{3.7}$$

Here $W_N[G]$ is the number of multiplications required to solve optimally the system having 'n' equations i.e. whose coefficient matrix has 'n' rows and G is the corresponding graph. The solution of these equation which is dynamic programming will yield the following result. At each step in the elimination scheme, eliminate that node next which has the smallest degree.

Such problems can easily be formulated and solved by the principle of dynamic programming which is developed by Richard Bellman because these problems belong to a category known as the multistage decision process, typical example being that of travelling sales man problem. Here we take the initial decision which is arbitrary and based upon this decision all other decisions are optimal, say in this particular case, the initial decision is that the ith row of the coefficient matrix 'A' is processed first i.e., ith node of the corresponding graph 'G' is eliminated first; because of taking this decision, the cost involved e_i where e_i indicates the number of multiplications needed to process

the i^{th} row of coefficient matrix A, will be the measure of the cost to process the ith row. Because of taking this decision, the graph 'G' will change to G^i and number of nodes will become (N-1) and hence the formulation using dynamic programming will yield the result,

$$W_N(G) = \min_i \; (e_i + W_{N-1}(G^i)) \qquad (3.8)$$

$$N = 1 \ldots n$$

The main advantage of using this formulation is; at any stage we deal with only one variable i.e. instead of solving all the n variables together, they are solved one at a time, however n number of times.

3.3 DIRECT SOLUTION OF SPARSE NETWORK EQUATIONS BY OPTIMALLY ORDERED ELIMINATION:

For the sparse systems, which normally occur in power system network formulation, solution is obtained by optimally ordered elimination. This method consists of two parts [9,10,11].

1) A scheme of recording the operation of triangular decomposition of a matrix such that repeated direct solution can be obtained without repeating the triangularization process.

2) A scheme of ordering the operation such that it tends to conserve sparsity of the original system.

The first part of the method is applicable to any matrix. However the application of the second part i.e. ordering to conserve sparsity is limited to sparse matrix in which the pattern of non-zero elements is symmetric and for which an arbitrary order of decomposition does not affect adversely the numerical accuracy, such matrices are normally characterized by a strong diagonal. The coefficient matrix in the case of the load flow problem belong to this category where more than 90% elements are zero at off diagonal locations. Let us take the equation

$[A]\ x = y$ which can be expanded as

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_n \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ \cdot \\ \cdot \\ \cdot \\ Y_n \end{bmatrix} \qquad (3.9)$$

The matrix 'A' is changed to augumented matrix A by adding in (n+1)th column, the known constants of column vector Y. By factored LU decomposition of the coefficient matrix, we obtain the following matrix known as the table of factors.

$$\begin{bmatrix} d_{11} & u_{12} & \cdots & u_{1n} & u_{1n+1} \\ \ell_{21} & d_{22} & \cdots & u_{2n} & u_{2n+1} \\ \vdots & \vdots & & \vdots & \vdots \\ \ell_{n1} & \ell_{n2} & \cdots & d_{nn} & u_{nn+1} \end{bmatrix} \qquad (3.10)$$

where the elements of the matrix are defined below

$$d_{ii} = \frac{1}{a_{ii}^{(i-1)}}$$

$$u_{ij} = a_{ij}^{(i)}$$

$$L_{ij} = a_{ij}^{(j-1)}$$

When the matrix to be decomposed is sparse the order in which the rows are processed affect the number of non-zero terms in the upper triangular matrix. If a programming scheme is such that it processes and stores,only the non-zero terms, a great swing in operation and memory can be achieved by keeping the table of factors as sparse as possible. The absolute optimal ordering scheme would result in the least terms in the table of factors.

However the absolute scheme of ordering has not been developed as yet, we give below the following effective scheme of near optimal ordering.

1. In this scheme the coefficient matrix of a physical system is ordered before hand. Here the rows with only one non-zero element at the off diagonal locations is numbered first-row with two non-zero elements is numbered two and so on. Finally the row with the maximum non-zero elements is numbered last. The rows of coefficient matrix A in the process of elimination, are processed in this sequence. From the graph point of view, a node with a degree one is numbered one, a node with a degree two is numbered two and finally the row with the highest degree is numbered last. This algorithm is simple to program and fast to execute , however the main disadvantage of the algorithm is that it does not take into account the changes in the pattern of non-zero elements in the coefficient matrix.

2. This algorithm has been derived by using the technique of dynamic programming by R. Bellman, In this algorithm, in the process of elimination, we eliminate that row next which has the minimum number of non-zero elements in the off-diagonal locations. From the graph point of view, we eliminate that node next which has minimum degree. This algorithm, even though, being more complex than the first one, is certainly more efficient because it takes into account the changes in the pattern of non-zero elements in the process of elimination.

3. In this algorithm, in the process of elimination, eliminate that row next whose elimination will introduce minimum number of non-zero elements in the off diagonal locations. From the graph point of view in the process of elimination, eliminate that node next whose elimination will introduce minimum number of new links in the system graph. This algorithm has not been used by us because it takes more time compared to (2). However, if the criteria is only to optimize the computer memory with cost having no consideration, this is certainly the best.

Algorithm (2) which claims to optimize both the computer memory and almost the computer time has been used by us. The input information in this case is a list by rows of the column numbers counting off diagonal non-zero terms (i.e. branches). This scheme no doubt is more efficient than the first one.

CHAPTER 4

LOAD FLOW ANALYSIS: CASE STUDIES

4.1 INTRODUCTION:

This chapter presents the load flow studies for the following systems.

1. 14 bus 20 lines IEEE system
2. 57 bus 80 lines IEEE system
3. 100 bus 128 lines UPSEB systems

These systems have been studied using the following methods.

1. Newton-Raphson method in polar coordinates
2. Decoupled method in polar coordinates
3. Fast Decoupled method

The choice of a particular method invariably depends upon the following factors.

1. Memory requirement
2. Speed
3. Accuracy

and 4. Convergence criterion

An attempt has been made in this chapter to compare the three methods based upon above mentioned criterion. The results of the systems studied and their significance are also discussed. The details of the study have been categorized method-wise.

Memory requirement and computer time invariably dictate the choice of method for load flow studies i.e. why NR method in polar coordinates has been chosen.

Accuracy and quadratic convergence properties of this method are offset by the memory and computational requirement Although programming technique is important in all load flow methods for obtaining fast execution and economy in storage, it is the cornerstone of methods such as Newton - Raphson. Thus in the case sparsity oriented programming makes all the difference, for without efficient storage and execution this method loses all its charm. To emphasize on the importance of sparsity oriented programming for these methods (especially NR method) two sets of programs are developed.

SET I: Full storage mode and gaussian elimination for solving the load flow equations.

SET II: Storing only non-zero elements of the Jacobian and Bus admittance matrix and ordered elimination of the load flow equations.

Each of the above mentioned sets offers a choice of three methods viz Newton-Raphson, Decoupled and Fast Decoup The details of memory requirement and computation time for method [for the systems studied] with and without sparsity oriented programming are given. Each method will be taken

up and studied with reference to the four factors mentioned before. The results of the sample systems are used as a means of comparing various criteria's.

4.2 NEWTON-RAPHSON METHOD :

The three systems are solved using this method. The Compu tation time for different systems (with and without the use of sparsity oriented programming) are listed in Table 4.1. If we consider the 14 bus system and compare the per iteration time in Case I and Case II we find that the difference does not justify the extra efforts involved in sparsity oriented programming, but a glance at the results for 57 bus and 100 bus system will speak otherwise. The iteration time in Case I is roughly five times that of Case II for a 57 bus system and twenty five times for a 100 bus system respectively.

The saving in terms of memory requirement is also tremendous. Table 4.2 gives the memory saved with sparsity oriented approach. [Only Jacobian and bus admittance matrix requirements are compared as they take the bulk of storage space. The data storage requirements being same for both cases].

The memory requirement and computation time per iteration for case II increases linearly with the number of buses. In contrast to this, for case I the memory requirement is

Table 4.1

14 bus system

Type	C.P.U. Time	No. of Iterations	Time per Iteration	Specified Tolerance ϵ	Achieved Tolerance
Without Sparsity (Case I)	1.19	3	0.396	0.001	0.00011
With Sparsity (Case II)	0.95	3	0.316	0.001	0.00011

57 bus system

Type	C.P.U. Time	No. of Iterations	Time per Iteration	Specified Tolerance ϵ	Achieved Tolerance
Without Sparsity (Case I)	34.02	4	8.505	0.001	0.00015
With Sparsity (Case II)	6.98	4	1.745	0.001	0.00015

100 bus system

Type	C.P.U. Time	No. of Iterations	Time per Iteration	Specified Tolerance ϵ	Achieved Tolerance
Without Sparsity (Case I)	624.84	7	89.26	0.001	0.00015
With Sparsity (Case II)	25.80	7	3.69	0.001	0.00015

Table 4.2

No. of buses	No. of P-V buses	Order of Jacobian	Order of Y_{Bus}	Without Sparsity (Case I)			With Sparsity (Case II)			Saving	% sav.
				Jacobian	Y_{Bus}	Total	Jacobian*	Y^*_{Bus}	Total		
14	5	22	14	484	392	876	438	216	654	222	25.34
57	7	106	57	11236	6498	17734	2154	852	3006	14728	83.05
100	19	180	100	32400	20000	52400	3702	1424	5126	47274	90.22

*This includes the storage needed for indexing information.

Table 4.3

14 bus system

Type	C.P.U. Time	Iterations	Time per Iteration	Specified ϵ_S	Achieved ϵ_A
Without Sparsity (Case I)	3.0	15	0.2	0.001	0.00097
With Sparsity (Case II)	2.16	15	0.144	0.001	0.00097

57 bus system

Type	C.P.U. Time	Iterations	Time per Iteration	Specified ϵ_S	Achieved ϵ_A
Without Sparsity (Case I)	14.56	7	2.08	0.06	0.051
With Sparsity (Case II)	10.38	7	1.48	0.06	0.051

100 bus system

Type	C.P.U. Time	Iterations	Time per Iteration	Specified ϵ_S	Achieved ϵ_A
Without Sparsity (Case I)	75.54	9	8.4	0.001	0.00048
With Sparsity (Case II)	32.0	9	3.56	0.001	0.00048

Table 4.4

No. of buses	No. of P-V buses	Order of Jacobian	Order of Y_{Bus}	Without Sparsity (Case I)			With Sparsity (Case II)			Saving	% sav
				Jacobian	Y_{Bus}	Total	Jacobian*	Y^*_{Bus}	Total		
14	5	13	14	169	392	561	147	216	363	198	35.29
57	7	56	57	3136	6498	9634	612	852	1464	8170	84.8
100	19	99	100	9801	20000	29801	1059	1424	2483	27318	91.6

*This includes the storage needed for indexing information.

roughly $5N^2$, where N is the number of buses. From the Table 4.1 and 4.2, it can be inferred that the Newton-Raphson method realizes its full potential only when it is used with sparsity ordered elimination, especially for a large scale system.

4.3 DECOUPLED METHOD:

Table 4.3 gives the computation time for the three syst

It is interesting to note that the decoupled technique, saves substantial amount of time, compared to Newton-Raphson method, for Case I, (compare tables 4.1 and 4.3 for Case I) but this saving is almost negligible when we compare for Case II, e.g. for 100 bus system, the iteration time for the Newton-Raphson method (case II) is 3.69 seconds while the corresponding time for Decoupled technique (case II) is 3.56 seconds. Table 4.4 gives the memory requirements for the Decoupled method. A comparison of Table 4.2 and Table 4.4, reveals the following.

<u>For Case I</u> : 100 bus system , Decoupled method requires 29801 words of memory as compared to 52400 in Newton-Raphson method. This amounts to a saving of 50%.

<u>For case II</u> : 100 bus system; Decoupled method requires 2473 words as compared to 5126 in Newton-Raphson method.

Although, the saving in this case is of the order of about 40% , its significance is not much because the absolute memory requirement has come down to a low level because of sparsity. Thus, when the sparsity and ordered eliminates are used, the Decoupled method is ruled out because memory requirement and computer time are almost same for both methods, hence one would prefer to make use of the more accurate method like Newton-Raphson with the added advantage of quadratic convergence (true quadratic convergence characteristics is lost in the Decoupled method).

4.4 FAST DECOUPLED METHOD:

Tables 4.5 and 4.6 give the computation time and memory requirement for the three systems. In this method, the iteration time is reduced to a great extent as compared with other methods. Memory requirements for this method are the same as that for Decoupled method. Quadratic convergence feature is lost in this method and thus we need a few additional iterations for convergence as compared to Newton-Raphson However the increase in overall time is not much because of the lower per iteration time.

4.5 Q LIMIT ADJUSTMENT:

Q limit adjustment is also tried out using the following three schemes.

Table 4.5

14 bus system

Type	C.P.U. Time	Iterations	Time per Iteration	Specified ϵ_S	Achieved ϵ_A
Without Sparsity (Case I)	1.38	10	0.138	0.001	0.00080
With Sparsity (Case II)	1.22	10	0.122	0.001	0.00080

57 bus system

Type	C.P.U. Time	Iterations	Time per Iteration	Specified ϵ_S	Achieved ϵ_A
Without Sparsity (Case I)	9.76	6	1.626	0.02	0.019
With Sparsity (Case II)	5.28	6	0.88	0.02	0.019

100 bus system

Type	C.P.U. Time	Iterations	Time per Iteration	Specified ϵ_S	Achieved ϵ_A
Without Sparsity (Case I)	52.57	7	7.51	0.001	0.00028
With Sparsity (Case II)	14	7	2.0	0.001	0.00028

Table 4.6

No. of buses	No. of P-V buses	Order of Jacobian	Order of Y_{Bus}	Without Sparsity (Case I)			With Sparsity (Case II)			Saving	% sav.
				Jacobian	Y_{Bus}	Total	Jacobian* +	Y^*_{Bus}	Total		
14	5	13	14	169	392	561	324	216	540	21	3.7%
57	7	56	57	3136	6498	9634	1278	852	2130	7504	77.9%
100	19	99	100	9801	20000	29801	2136	1424	3560	26241	88.05%

*This includes storage needed for indexing information.

+In case Table of factors for both B' and B'' are stored. (If Table of factors B' and B'' are not stored then memory requirement is almost the same as that for Decoupled method).

1. P-V to P-Q switching
2. Voltage perturbation
3. Voltage perturbation using feedback

The flow chart for the above mentioned methods are attached alongwith.

All these have not worked out very neatly. P-V to P-Q switching scheme works well for the 57 bus system, probably because of the number of P-V buses is not very large. When applied to the 100 bus system with 19 P-V buses (including slack) violations keep occuring at every iteration and the solution does not converge. The addition of soft constraints reduced the number of violations but without appreciable overall gain. In the voltage perturbation method the voltage of the P-V bus is perturbed slightly to 0.1% for 57 bus and 0.5% for 100 bus system to adjust the Q limits. The bus is treated as a P-V bus throughout. In this case convergence is obtained in an iteration when Q is being violated at one of the buses (bus No. 73 for the 100 bus case). Also, the Q at other P-V buses goes too far inside the Q limits.

In the third scheme, although the Q at most of the buses is within the tolerance band, yet, at one of the buses it is completely out of limit. This is because, the solution converges when the Q violation takes place at one of the

bus. If we introduce the constraint that both should be satisfied simultaneously then it does not converge at all.

All the schemes (1,2,and 3) have been tried out only in the case of Newton-Raphson method.

It is clear that the success in all the above schemes especially schemes 2 and 3 is due to various empirical adjustments. At the same time, the adjustments are system dependent i.e. they may work for a particular system only (this is true for voltage perturbation scheme no. 2).

The flow diagrams data and load flow results for the three systems by various methods have been attached alongwith. It is to be noted that for the 100 bus problem, results are for the adjusted solution with scheme (3). An unadjusted solution takes 4 iterations (Q's being violated at 6 buses) and 16.6 seconds. The results with Decoupled and Fast Decoupled methods using scheme 2, are also inclosed. It is to be noted that the unadjusted solution will require lesser number of iterations.

CHAPTER 5

CONCLUSION

The main objective of this thesis has been to present a detailed comparative study of Newton-Raphson, Decoupled and Fast Decoupled methods. The importance of any load flow solution depends largely upon its merits regarding reliability, convergence characteristics, solution time and memory requirements. The above methods differ, most, in their memory and computation time requirements. Keeping this in view, a comparative study of the aforementional methods has been made. In order to optimize computational time, the emphasis has been on the sparsity oriented programming approach. From the results obtained in this thesis, it is clear that this approach optimizes memory and/or computational time. The full potential of these methods is realized only when memory and computation time are optimized by the application of sparsity oriented programming techniques.

For practical power system, various additional features, should be incorporated in the load flow program. These additional features are in the form of Q limits, variable transformer taps etc. The schemes tried out here for the Q limit, have not yielded satisfactory results. It is felt that the addition of these features in the load flow program would further enhance its utility.

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APPENDIX

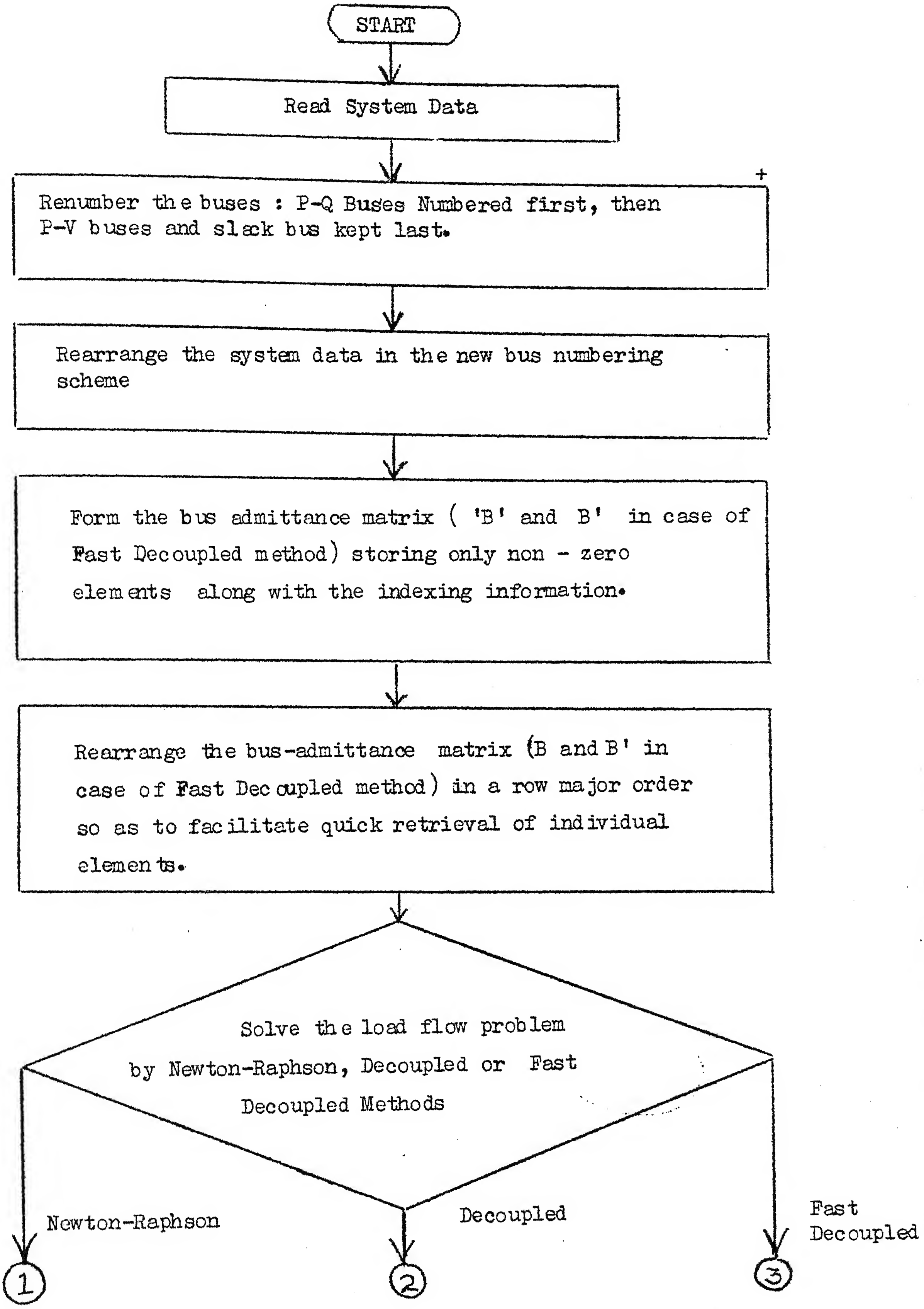
The general 'continuous feedback' adjustment formula is

$$\Delta x = \alpha \Delta Y$$

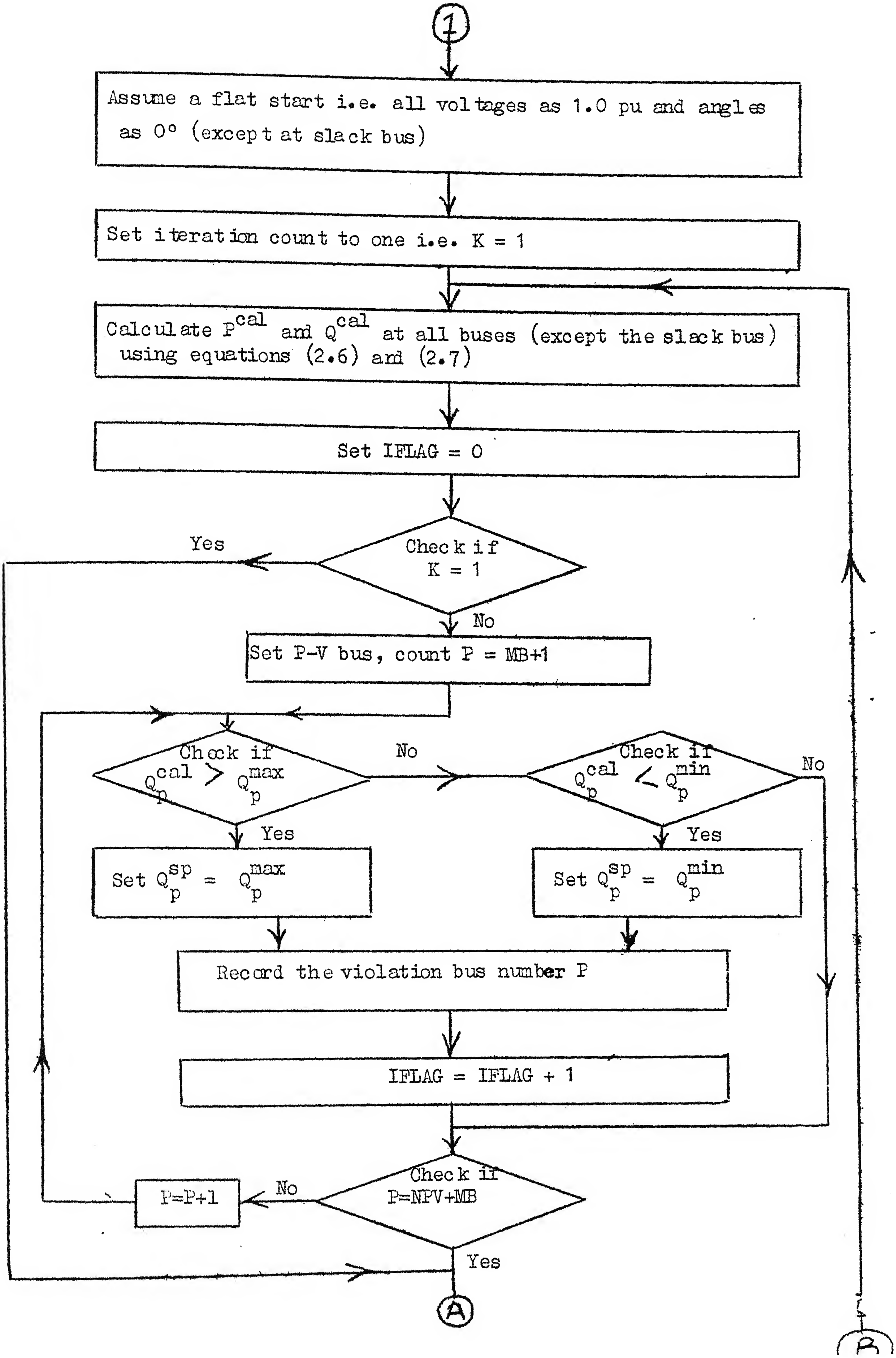
where α is the 'feedback gain' whose choice is important fc each type of control, each load flow method, and in some cases each system. The objective in choosing α is to minimise the total number of iterations while preserving reliable convergence. The slowly converging methods tend to suffer much less than the fast converging ones from the effects of the adjustments. The value of α can be choosen empirically to suit a particular system or else should be approximately the sensitivity between x and y at the operating point. For a given system, a suitable fixed estimate of this can be calculated or found empirically.

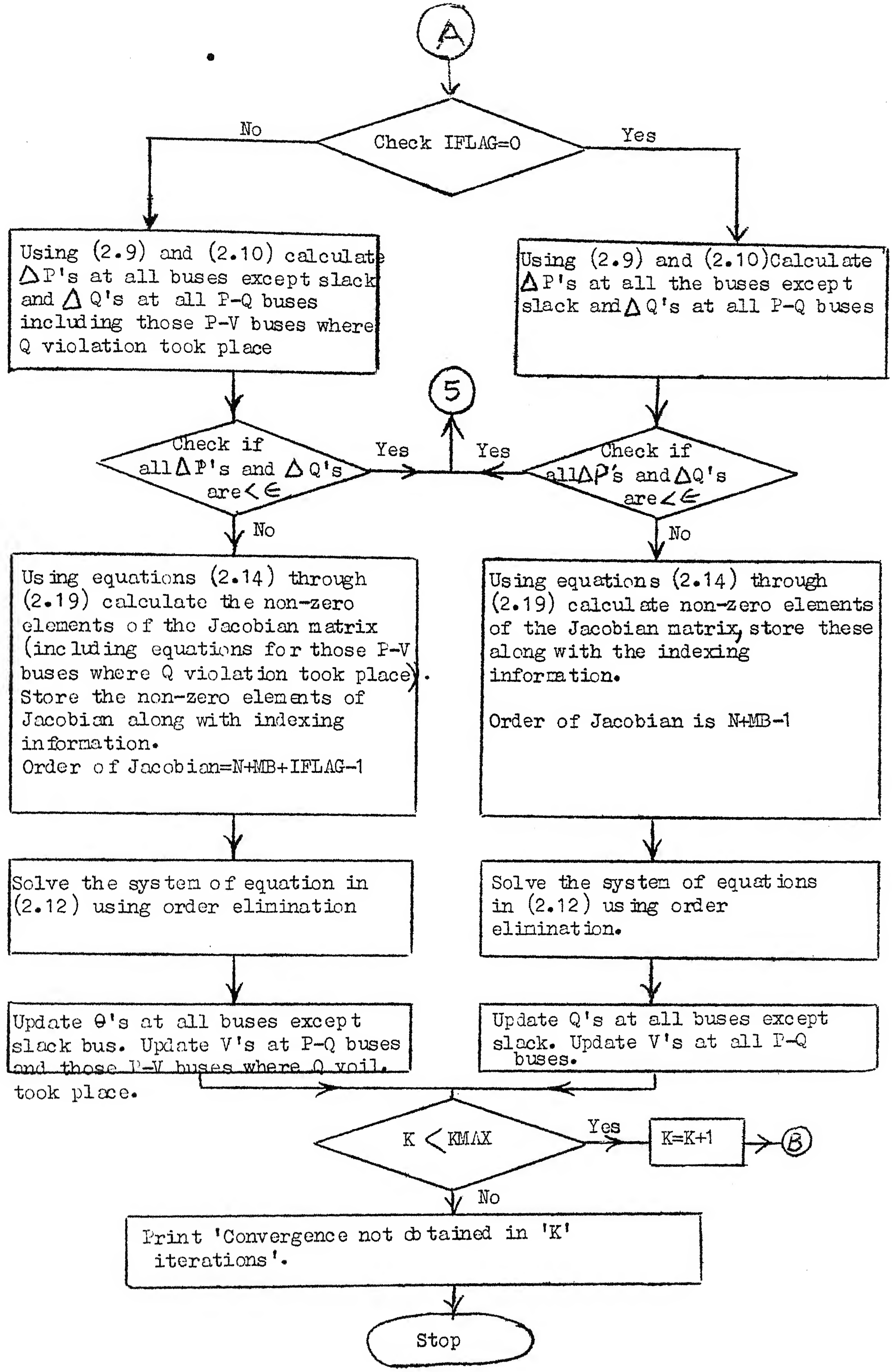
When the adjustment process is initiated, a trial correction $\Delta x^{(1)}$ (not too small) is made on the basis of an error $\Delta y^{(0)}$. One or more load flow iterations are then performed until moderate convergence is achieved, and the new error is $y^{(1)}$. An estimate of α can now be found thus,

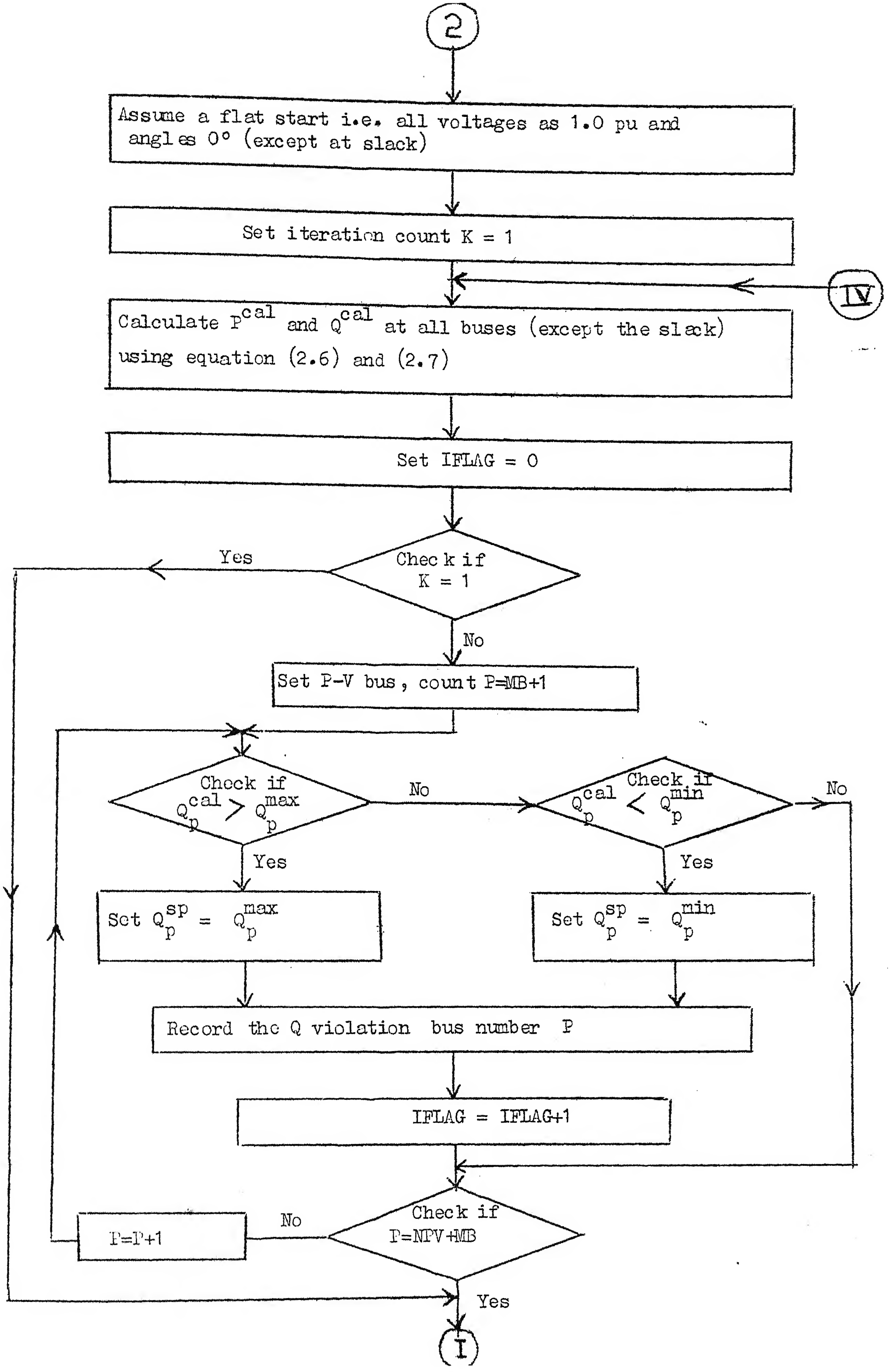
$$\alpha = \Delta x^{(1)} / (\Delta y^{(1)} - \Delta y^{(0)})$$

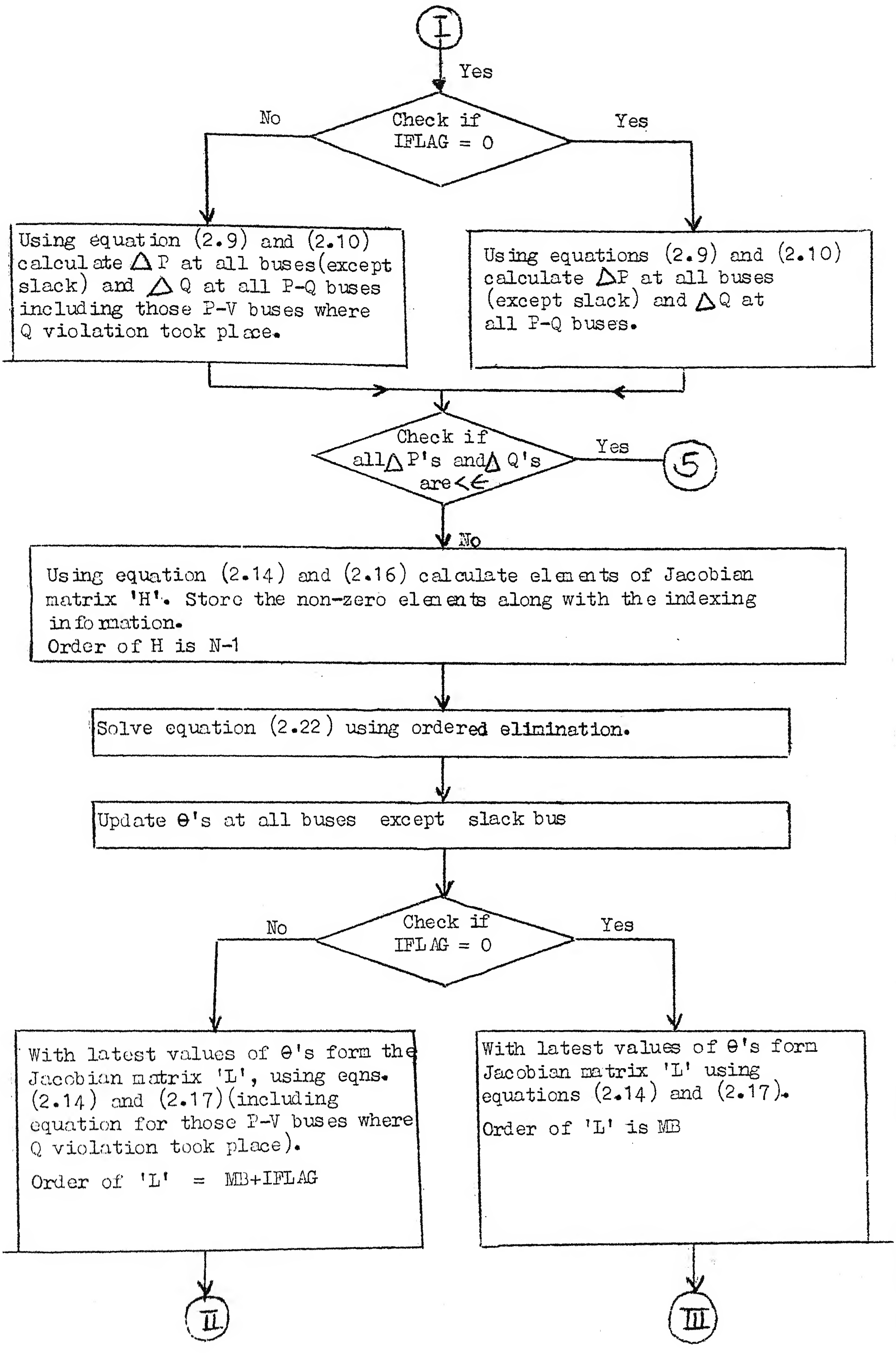


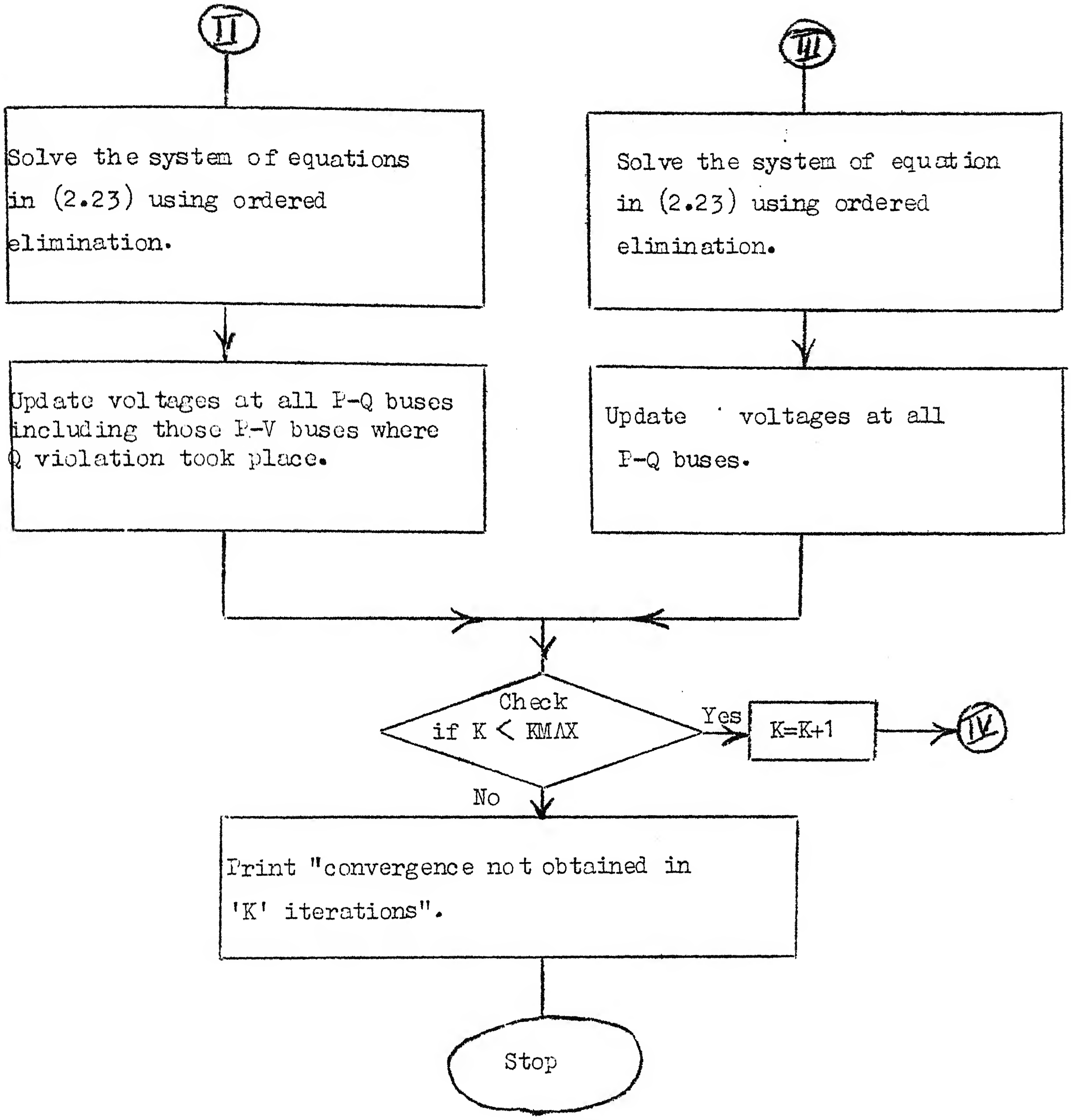
Flow Chart for the Newton-Raphson, Decoupled and Fast Decoupled methods using Sparsity and ordered elimination.

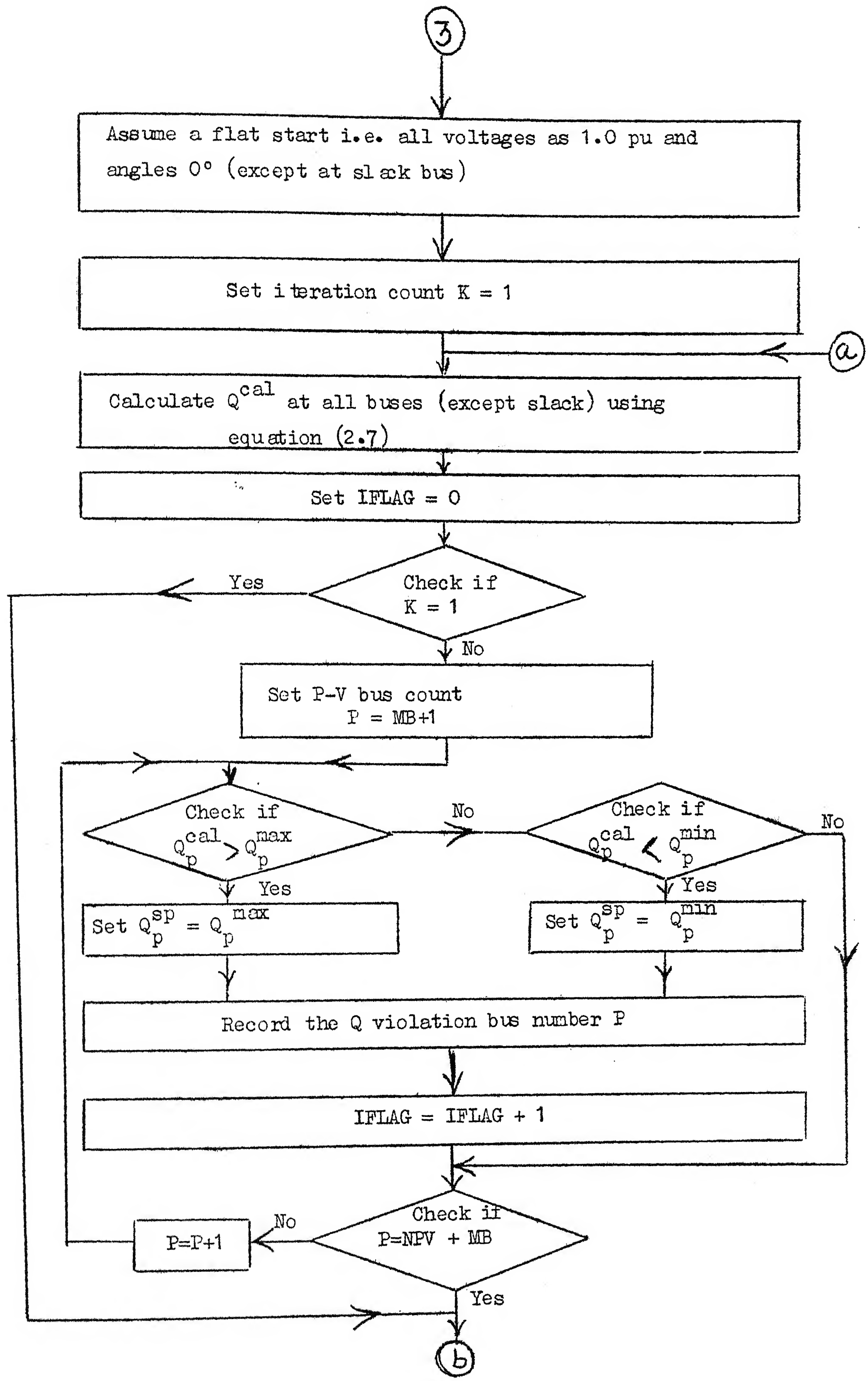

1
Assume a flat start i.e. all voltages as 1.0 pu and angles as 0° (except at slack bus)
Set iteration count to one i.e. K = 1
Calculate P^{cal} and Q^{cal} at all buses (except the slack bus) using equations (2.6) and (2.7)
Set IFLAG = 0
Check if K = 1
Yes
No
Set P-V bus, count P = MB+1
Check if $Q_p^{cal} > Q_p^{max}$
No
Check if $Q_p^{cal} < Q_p^{min}$
No
Yes
Set $Q_p^{sp} = Q_p^{max}$
Yes
Set $Q_p^{sp} = Q_p^{min}$
Record the violation bus number P
IFLAG = IFLAG + 1
Check if P=NPV+MB
No
P=P+1
Yes
A
B

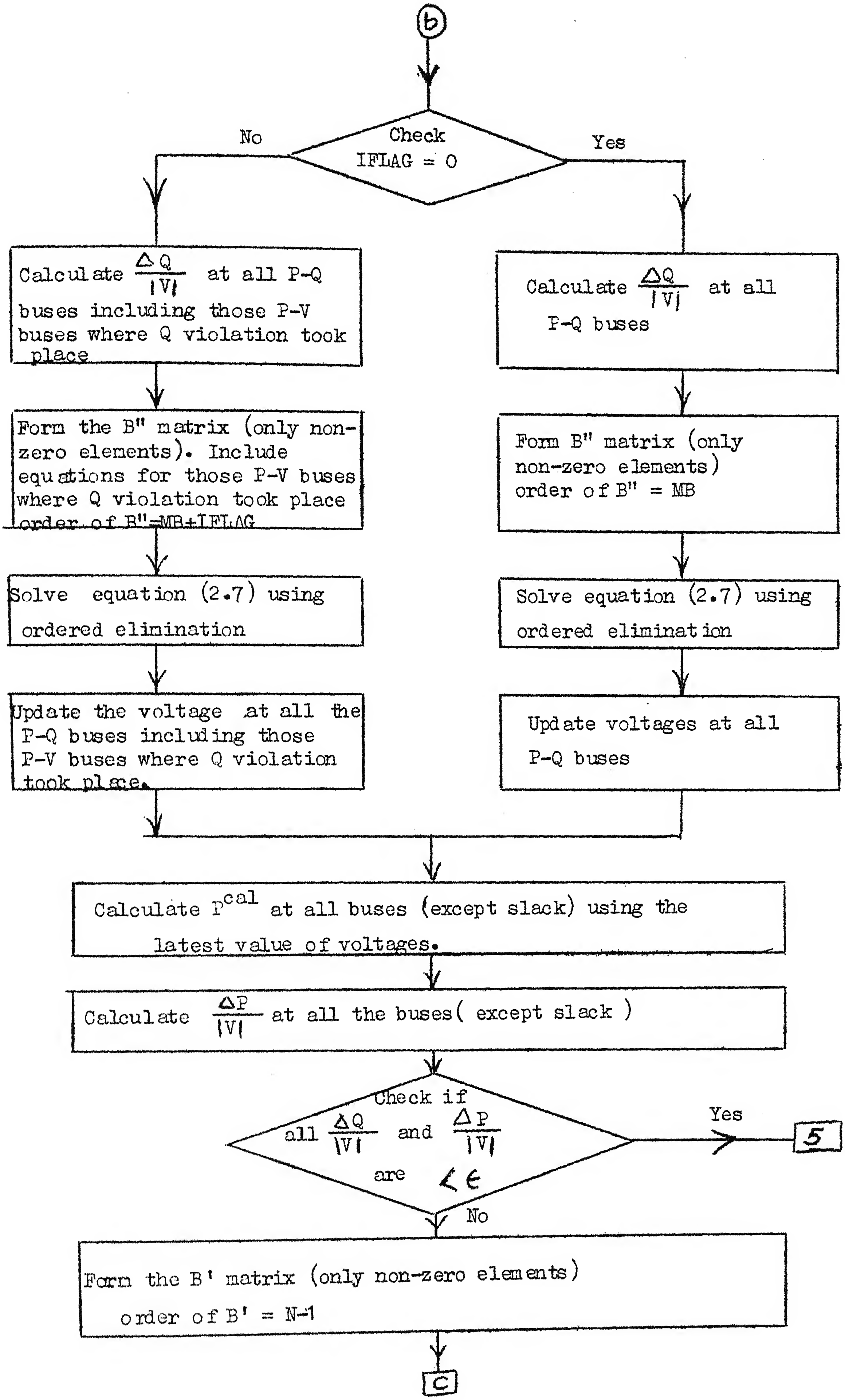

A
Check IFLAG=0
No
Yes
Using (2.9) and (2.10) calculate ΔP's at all buses except slack and ΔQ's at all P-Q buses including those P-V buses where Q violation took place
Using (2.9) and (2.10)Calculate ΔP's at all the buses except slack and ΔQ's at all P-Q buses
5
Check if all ΔP's and ΔQ's are < ∈
Yes
Yes
Check if allΔP's and ΔQ's are < ∈
No
No
Using equations (2.14) through (2.19) calculate the non-zero elements of the Jacobian matrix (including equations for those P-V buses where Q violation took place). Store the non-zero elements of Jacobian along with indexing information.
Order of Jacobian=N+MB+IFLAG-1
Using equations (2.14) through (2.19) calculate non-zero elements of the Jacobian matrix, store these along with the indexing information.
Order of Jacobian is N+MB-1
Solve the system of equation in (2.12) using order elimination
Solve the system of equations in (2.12) using order elimination.
Update θ's at all buses except slack bus. Update V's at P-Q buses and those P-V buses where Q voil. took place.
Update Q's at all buses except slack. Update V's at all P-Q buses.
K < KMAX
Yes
K=K+1
B
No
Print 'Convergence not obtained in 'K' iterations'.
Stop

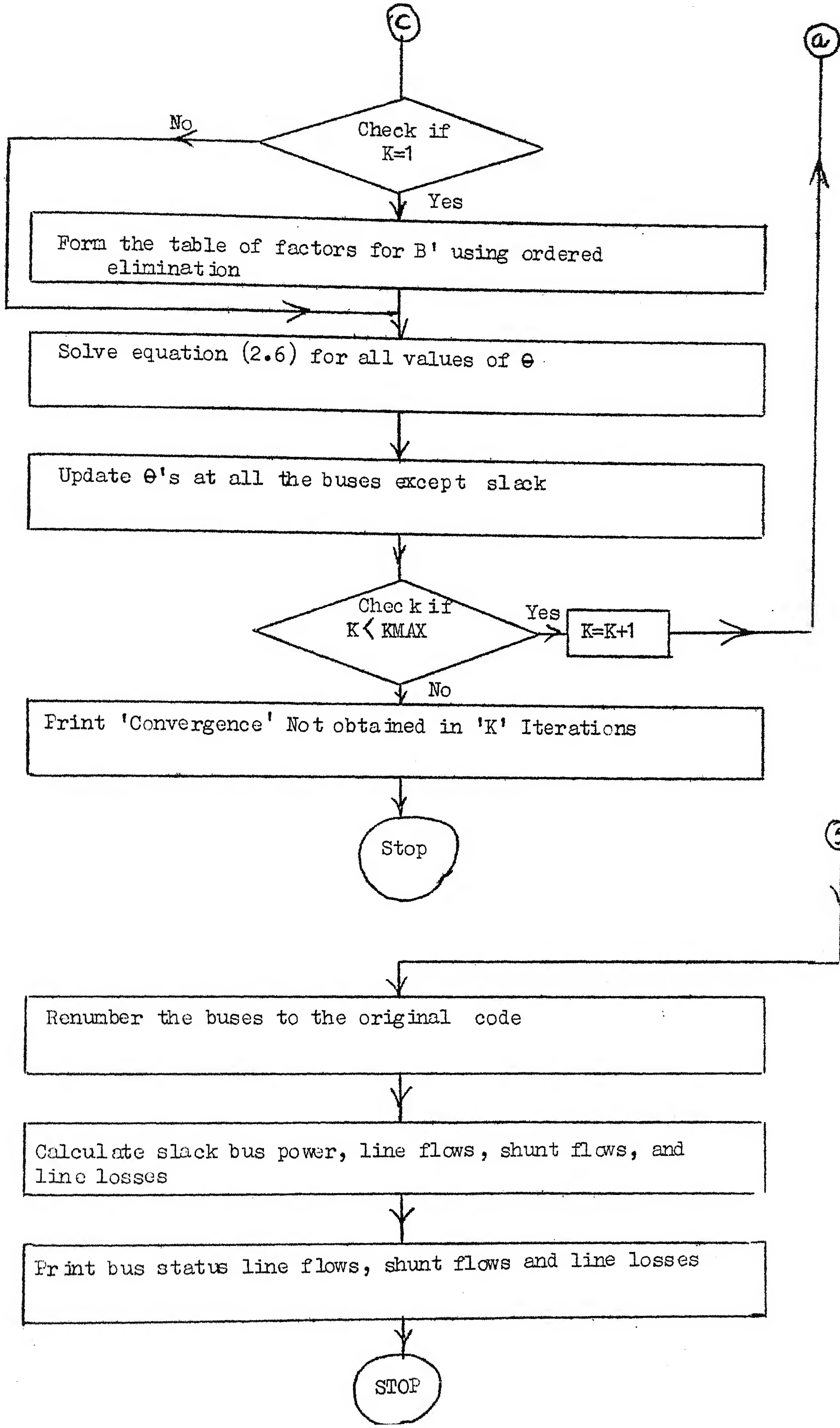

2
Assume a flat start i.e. all voltages as 1.0 pu and angles 0° (except at slack)
Set iteration count K = 1
IV
Calculate P^{cal} and Q^{cal} at all buses (except the slack) using equation (2.6) and (2.7)
Set IFLAG = 0
Check if K = 1
Yes
No
Set P-V bus, count P=MB+1
Check if $Q_p^{cal} > Q_p^{max}$
No
Check if $Q_p^{cal} < Q_p^{min}$
No
Yes
Yes
Set $Q_p^{sp} = Q_p^{max}$
Set $Q_p^{sp} = Q_p^{min}$
Record the Q violation bus number P
IFLAG = IFLAG+1
Check if P=NPV+MB
No
P=P+1
Yes
I

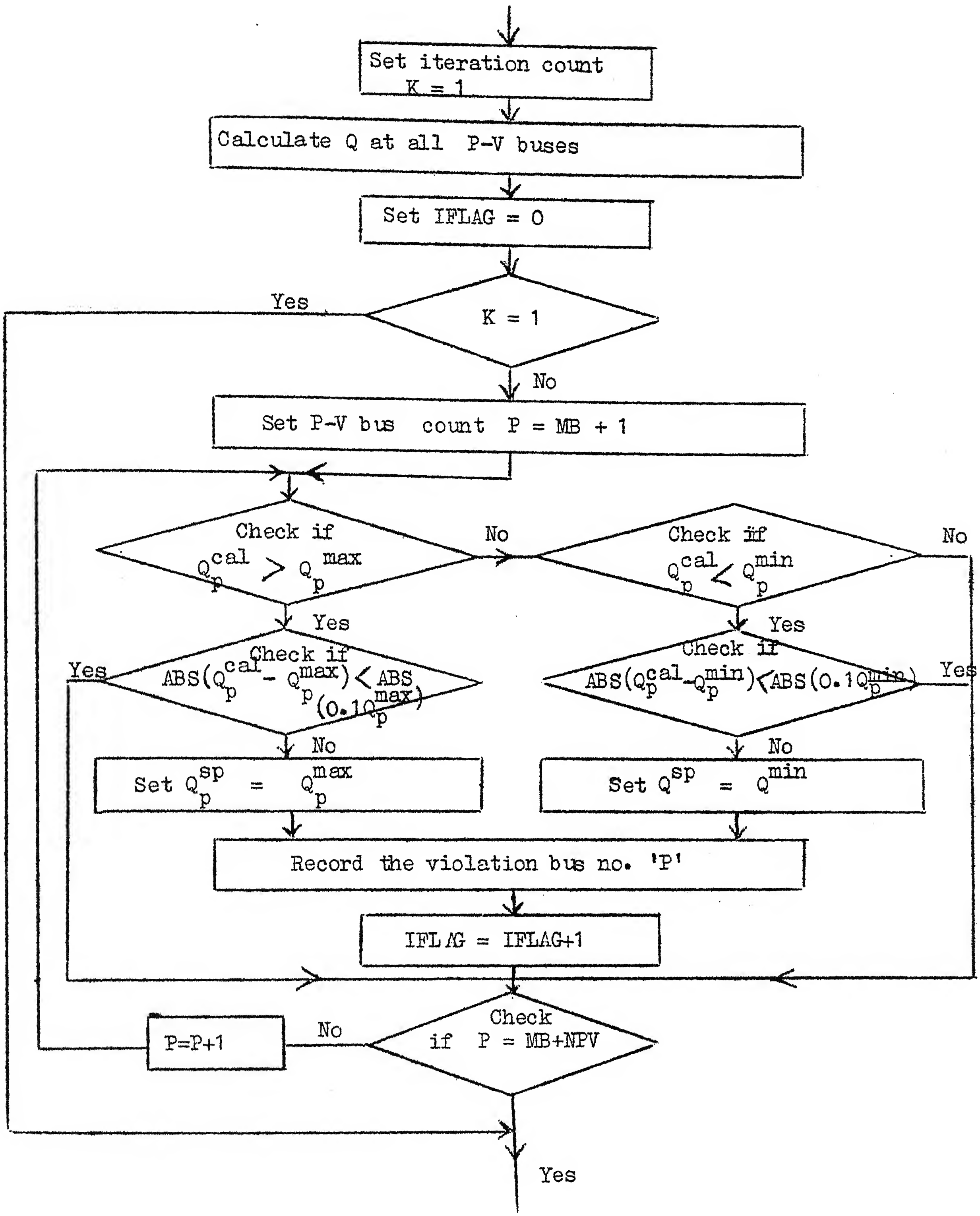

I
Yes
Check if IFLAG = 0
No
Yes
Using equation (2.9) and (2.10) calculate ΔP at all buses(except slack) and ΔQ at all P-Q buses including those P-V buses where Q violation took place.
Using equations (2.9) and (2.10) calculate ΔP at all buses (except slack) and ΔQ at all P-Q buses.
Check if all ΔP's and ΔQ's are $< \epsilon$
Yes
5
No
Using equation (2.14) and (2.16) calculate elements of Jacobian matrix 'H'. Store the non-zero elements along with the indexing information.
Order of H is N-1
Solve equation (2.22) using ordered elimination.
Update θ's at all buses except slack bus
Check if IFLAG = 0
No
Yes
With latest values of θ's form the Jacobian matrix 'L', using eqns. (2.14) and (2.17)(including equation for those P-V buses where Q violation took place).
Order of 'L' = MB+IFLAG
With latest values of θ's form Jacobian matrix 'L' using equations (2.14) and (2.17).
Order of 'L' is MB
II
III


II
III
Solve the system of equations in (2.23) using ordered elimination.
Solve the system of equation in (2.23) using ordered elimination.
Update voltages at all P-Q buses including those P-V buses where Q violation took place.
Update voltages at all P-Q buses.
Check if K < KMAX
Yes
K=K+1
IV
No
Print "convergence not obtained in 'K' iterations".
Stop

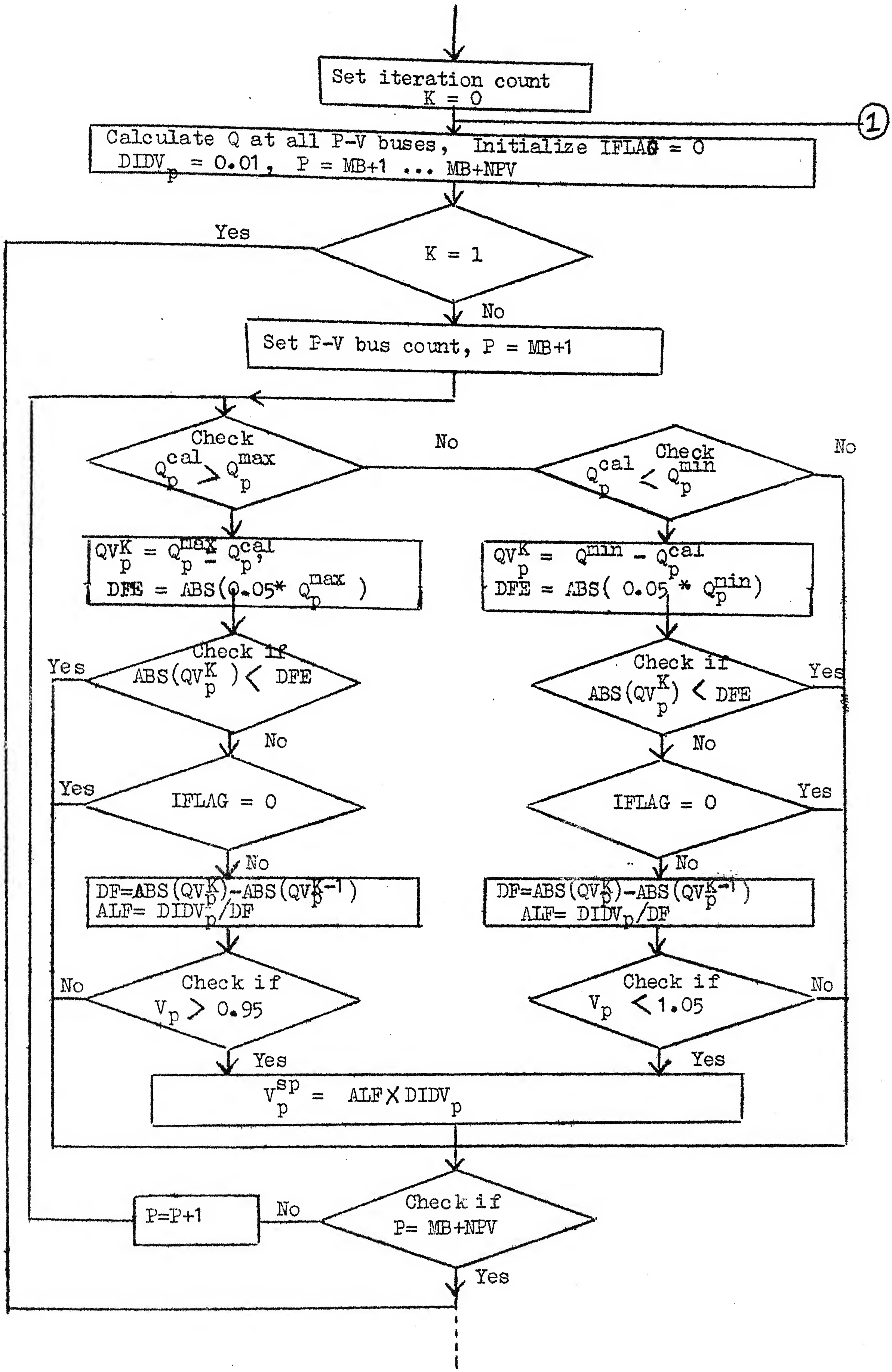

3
Assume a flat start i.e. all voltages as 1.0 pu and angles 0° (except at slack bus)
Set iteration count K = 1
a
Calculate Q^{cal} at all buses (except slack) using equation (2.7)
Set IFLAG = 0
Check if K = 1
Yes
No
Set P-V bus count P = MB+1
Check if $Q_p^{cal} > Q_p^{max}$
No
Yes
Set $Q_p^{sp} = Q_p^{max}$
Check if $Q_p^{cal} < Q_p^{min}$
No
Yes
Set $Q_p^{sp} = Q_p^{min}$
Record the Q violation bus number P
IFLAG = IFLAG + 1
Check if P=NPV + MB
No
P=P+1
Yes
b

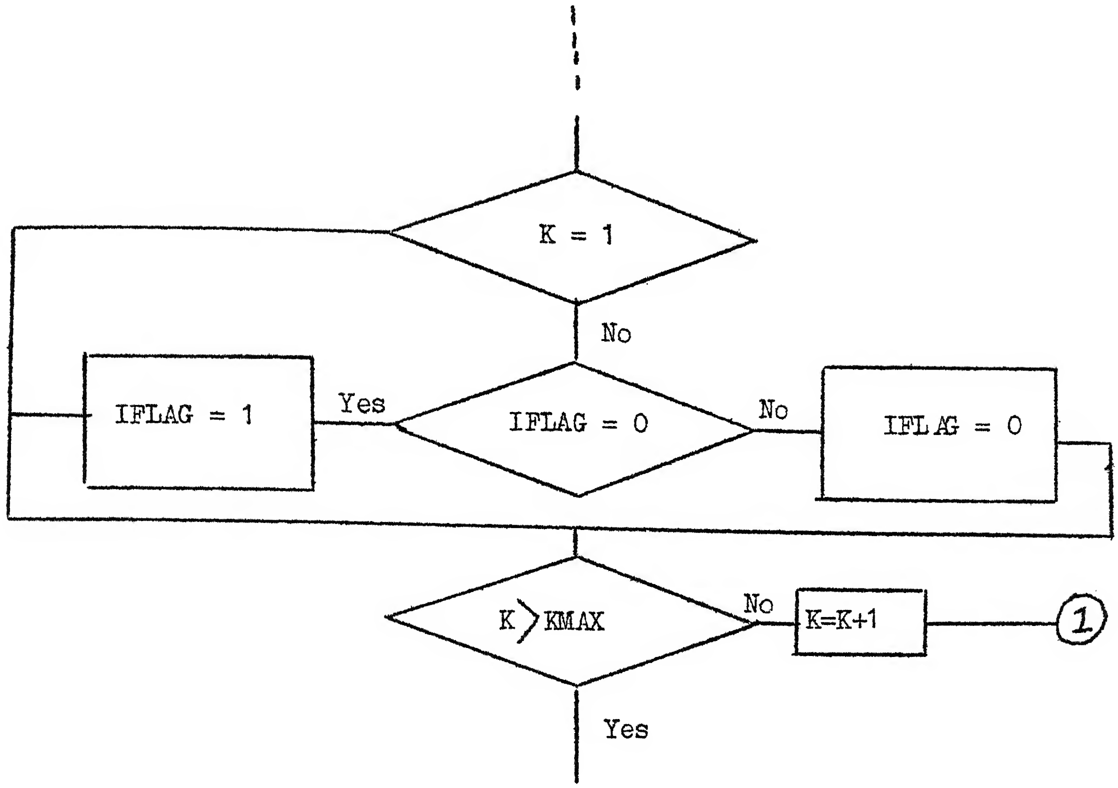

b
Check IFLAG = 0
No
Yes
Calculate $\frac{\Delta Q}{|V|}$ at all P-Q buses including those P-V buses where Q violation took place
Form the B" matrix (only non-zero elements). Include equations for those P-V buses where Q violation took place order of B"=MB+IFLAG
Solve equation (2.7) using ordered elimination
Update the voltage at all the P-Q buses including those P-V buses where Q violation took place.
Calculate $\frac{\Delta Q}{|V|}$ at all P-Q buses
Form B" matrix (only non-zero elements) order of B" = MB
Solve equation (2.7) using ordered elimination
Update voltages at all P-Q buses
Calculate P^{cal} at all buses (except slack) using the latest value of voltages.
Calculate $\frac{\Delta P}{|V|}$ at all the buses(except slack)
Check if all $\frac{\Delta Q}{|V|}$ and $\frac{\Delta P}{|V|}$ are $< \epsilon$
Yes
5
No
Form the B' matrix (only non-zero elements) order of B' = N-1
C


C
a
Check if
K=1
No
Yes
Form the table of factors for B' using ordered elimination
Solve equation (2.6) for all values of θ
Update θ's at all the buses except slack
Check if
K < KMAX
Yes
K=K+1
No
Print 'Convergence' Not obtained in 'K' Iterations
Stop
5
Renumber the buses to the original code
Calculate slack bus power, line flows, shunt flows, and line losses
Print bus status line flows, shunt flows and line losses
STOP



Q limits with P-V to P-Q switching (with soft constrants)


Set iteration count K = 0
1
Calculate Q at all P-V buses, Initialize IFLAG = 0
DIDV$_p$ = 0.01, P = MB+1 ... MB+NPV
K = 1
Yes
No
Set P-V bus count, P = MB+1
Check $Q_p^{cal} > Q_p^{max}$
No
Check $Q_p^{cal} < Q_p^{min}$
No
$QV_p^K = Q_p^{max} - Q_p^{cal}$,
DFE = ABS(0.05* Q_p^{max})
$QV_p^K = Q^{min} - Q_p^{cal}$
DFE = ABS(0.05 * Q_p^{min})
Check if ABS(QV_p^K) < DFE
Yes
No
Check if ABS(QV_p^K) < DFE
Yes
No
IFLAG = 0
Yes
No
IFLAG = 0
Yes
No
DF=ABS(QV_p^K)-ABS(QV_p^{K-1})
ALF= DIDV$_p$/DF
DF=ABS(QV_p^K)-ABS(QV_p^{K-1})
ALF= DIDV$_p$/DF
Check if V_p > 0.95
No
Yes
Check if V_p < 1.05
No
Yes
V_p^{sp} = ALF X DIDV$_p$
Check if P= MB+NPV
No
P=P+1
Yes



Q-limits using error feed back principle with soft constraints

NOTE: For N bus system
Let P-Q buses = MB
and P-V Buses = NPV
(Not including slack)

Then after renumbering as in block two of flow chart.+

Bus No. 1 to MB will be P-Q buses

Bus No. MB+1 to MB+NPV will be P-V buses

Bus No. MB+NPV+1 will be slack bus

IEEE 14 BUS SYSTEM FROM M.A.PAI

IPDATA = ? ISWICH = 0 INETH = 3 ICHOIC = 0 ISTART = 0

NO. OF STUDIES = 1 PRINT OPTIONS = 2 2 2 2 2 2

LIST OF INPUT DATA

NO. OF BUSES	NO. OF LINES	SLACK BUS	VOLT. CONT BUSES	SHUNT LOADS	MAX. ITERATIONS	CONV. LIMIT	BASE POWER
14	20	14	5	1	10	.00100000	100.00

BUS DATA

BUS NO.	NAME	GENERATION		LOAD POWER		ASSUMED BUS VOLTAGES VOLT MAG	PHASE ANGLE
1	1	0.0000	0.0000	14.9000	5.0000	1.0000	0.0000
2	2	40.0000	0.0000	21.7000	12.7000	1.0000	0.0000
3	3	0.0000	0.0000	94.2000	19.0000	1.0000	0.0000
4	4	0.0000	0.0000	47.8000	3.9000	1.0000	0.0000
5	5	0.0000	0.0000	7.6000	1.6000	1.0000	0.0000
6	6	0.0000	0.0000	11.2000	7.5000	1.0000	0.0000
7	7	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
8	8	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
9	9	0.0000	0.0000	29.5000	16.6000	1.0000	0.0000
10	10	0.0000	0.0000	9.0000	5.8000	1.0000	0.0000
11	11	0.0000	0.0000	3.5000	1.8000	1.0000	0.0000
12	12	0.0000	0.0000	6.1000	1.6000	1.0000	0.0000
13	13	0.0000	0.0000	13.5000	5.8000	1.0000	0.0000
14	14	232.4000	0.0000	0.0000	0.0000	1.0000	0.0000

LINE DATA

LINE NUMBER	FROM BUS		TO BUS		LINE IMPEDENCE		HALF LINE CHARG ADMIT		OFF NOM TR TURNS RATIO
1	14	14	2	2	0.01938	0.05917	0.00000	0.02640	1.00000
2	2	2	3	3	0.04699	0.19797	0.00000	0.02190	1.00000
3	2	2	4	4	0.05811	0.17632	0.00000	0.01870	1.00000
4	14	14	5	5	0.05403	0.22304	0.00000	0.02460	1.00000
5	2	2	5	5	0.05695	0.17388	0.00000	0.01700	1.00000
6	3	3	4	4	0.06701	0.17103	0.00000	0.01730	1.00000
7	4	4	5	5	0.01335	0.04211	0.00000	0.00640	1.00000
8	5	5	6	6	0.00000	0.25202	0.00000	0.00000	0.93200
9	4	4	7	7	0.00000	0.20912	0.00000	0.00000	0.97800
10	7	7	8	8	0.00000	0.17615	0.00000	0.00000	1.00000
11	4	4	9	9	0.00000	0.55618	0.00000	0.00000	0.96900
12	7	7	9	9	0.00000	0.11001	0.00000	0.00000	1.00000
13	9	9	10	10	0.03181	0.08450	0.00000	0.00000	1.00000
14	6	6	11	11	0.09498	0.19890	0.00000	0.00000	1.00000
15	6	6	12	12	0.12291	0.25581	0.00000	0.00000	1.00000
16	6	6	13	13	0.06615	0.13027	0.00000	0.00000	1.00000
17	9	9	1	1	0.12711	0.27038	0.00000	0.00000	1.00000
18	10	10	11	11	0.08205	0.19207	[illegible]		
19	12	12	[illegible]						

20	13	13	1	1	0.17093	0.[illegible]262	0.00000	[illegible].00000	1.00000

VOLTAGE CONTROLLED BUS DATA

S.NO.	BUS NO.	NAME	Q-MINIMUM	Q-MAXIMUM	SCHEDULED VOLTAGE
1	2	2	-40.0000	50.0000	1.0450
2	3	3	0.0000	40.0000	1.0100
3	6	6	-6.0000	24.0000	1.0700
4	8	8	-6.0000	24.0000	1.0900
5	14	14	-50.0000	50.0000	1.0600

SHUNT LOAD DATA

S.NO.	BUS NO.	NAME	SHUNT LOAD AVAILABLE	
1	9	9	0.00000	0.19000

LIST OF OUTPUT RESULTS

DMAX = 0.00010747 EPSIL = 0.00100000

NEWTON RAPHSON ITERATIVE TECHNIQUE CONVERGED IN 3 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1	1	1.03493	-16.01691	0.00000	-0.00158	14.90000	5.00000
2	2	1.04500	-4.98764	40.00001	46.42903	21.70000	12.70000
3	3	1.01000	-12.74697	0.00000	25.69310	94.20000	19.00000
4	4	1.01478	-10.27669	-0.00001	0.00353	47.80000	3.90000
5	5	1.01730	-8.74804	0.00005	0.01075	7.60000	1.60000
6	6	1.07000	-14.21306	0.00002	11.66731	11.20000	7.50000
7	7	1.06049	-13.33458	-0.00007	-0.00215	0.00000	0.00000
8	8	1.09000	-13.33458	0.00000	18.26026	0.00000	0.00000
9	9	1.05500	-14.91512	0.00005	-0.00764	29.50000	16.60000
10	10	1.05021	-15.07643	0.00001	-0.00084	9.00000	5.80000
11	11	1.05651	-14.77564	-0.00001	0.00038	3.50000	1.80000
12	12	1.05512	-15.06733	-0.00000	0.00006	6.10000	1.60000
13	13	1.05024	-15.14607	0.00000	0.00055	13.50000	5.80000
14	14	1.06000	0.00000	232.42153	-15.54653	0.00000	0.00000

TOTAL GENERATION = 272.421650 86.501236 TOTAL LOAD = 259.000000 81.300001 TOTAL LOSSES = 13.421650 5.201235

LIST OF OUTPUT RESULTS

DMAX = 0.00097355 EPSIL = 0.00100000

[illegible] ITERATIVE TECHNIQUE CONVERGED IN 15 ITERATIONS

[illegible]	[illegible]	VOLTAGE	ANGLE	GENERATION		LOAD	
1	1	1.03[illegible]	-15.01573	-0.00101	0.00112	14.90000	5.00000
2	2	1.04500	-4.98766	39.99978	45.43315	21.70000	12.70000
3	3	1.01000	-12.72702	-0.00023	25.69476	94.20000	19.00000
4	4	1.01478	-10.27868	0.00111	-0.00128	47.80000	3.90000
5	5	1.01729	-8.74803	-0.00037	0.00139	7.60000	1.60000
6	6	1.07000	-14.21327	0.00161	11.66063	11.20000	7.50000
7	7	1.05049	-13.33451	0.00012	-0.00011	0.00000	0.00000
8	8	1.09000	-13.33451	0.00000	18.25787	0.00000	0.00000
9	9	1.05500	-14.91592	-0.00304	0.00299	29.50000	16.60000
10	10	1.05022	-15.07639	0.00011	-0.00013	9.00000	5.80000
11	11	1.05651	-14.77572	-0.00007	-0.05025	3.50000	1.80000
12	12	1.05515	-15.07156	-0.07082	0.03339	6.10000	1.60000
13	13	1.05023	-15.14505	0.07726	-0.09735	13.50000	5.80000
14	14	1.06000	0.00000	232.42230	-15.54476	0.00000	0.00000

TAL GENERATION = 272.421720 86.501402 TOTAL LOAD = 259.000000 81.300001 TOTAL LOSSES = 13.421719 5.201401

LIST OF OUTPUT RESULTS

DMAX = 0.00080804 EPSIL = 0.00100000

FAST DECOUPLED ITERATIVE TECHNIQUE CONVERGED IN 10 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1	1	1.03493	-16.01756	0.00126	-0.00098	14.90000	5.00000
2	2	1.04500	-4.98765	40.00021	46.43231	21.70000	12.70000
3	3	1.01000	-12.74701	0.00024	25.69408	94.20000	19.00000
[illegible]	4	1.01472	-10.27871	-0.00084	0.00104	47.80000	3.90000
5	5	1.01729	-8.74799	0.00004	-0.00081	7.60000	1.60000
6	6	1.07000	-14.21284	-0.00024	11.66201	11.20000	7.50000
7	7	1.06049	-13.33468	-0.00009	0.00011	0.00000	0.00000
8	8	1.09000	-13.33468	0.00000	18.25640	0.00000	0.00000
9	9	1.05500	-14.91524	0.00303	-0.00291	29.50000	16.60000
10	10	1.05022	-15.07651	-0.00002	0.00008	9.00000	5.80000
11	11	1.05651	-14.77558	-0.00026	0.00033	3.50000	1.80000
12	12	1.05517	-15.06373	0.06976	-0.08129	6.10000	1.60000
13	13	1.05022	-15.14748	-0.07270	0.08487	13.50000	5.80000
14	14	1.06000	0.00000	232.42164	-15.54463	0.00000	0.00000

TOTAL GENERATION = 272.422040 36.500603 TOTAL LOAD = 259.000000 81.300001 TOTAL LOSSES = 13.422039 5.200602

L.F.STUDY(85-86-CEA),WITHOUT ADDING ANY NEW 400KV LINE

IPDATA = 0 IS-ITH = 0 IMETH = 3 ICHOIC = 0 ISTART = 0

NO. OF STUDIES = 1 PRINT OPTIONS = 2 2 2 2 2 2

LIST OF INPUT DATA

NO. OF BUSES	NO. OF LINES	SLACK BUS	VOLT. CONT BUSES	SHUNT LOADS	MAX. ITERATIONS	CONV. LIMIT
57	80	57	7	1	10	.02000000

BUS DATA

BUS NO. NAME	GENERATION		LOAD POWER		ASSUMED BUS VOLTAGES VOLT MAG	PHASE ANGLE
1	0.0000	0.0000	3.0000	88.0000	1.0000	0.0000
2	40.0000	0.0000	41.0000	21.0000	1.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
4	0.0000	0.0000	13.0000	4.0000	1.0000	0.0000
5	0.0000	0.0000	75.0000	2.0000	1.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
7	450.0000	0.0000	150.0000	22.0000	1.0000	0.0000
8	0.0000	0.0000	121.0000	26.0000	1.0000	0.0000
9	0.0000	0.0000	5.0000	2.0000	1.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
11	310.0000	0.0000	377.0000	24.0000	1.0000	0.0000
12	0.0000	0.0000	18.0000	2.3000	1.0000	0.0000
13	0.0000	0.0000	10.5000	5.3000	1.0000	0.0000
14	0.0000	0.0000	22.0000	5.0000	1.0000	0.0000
15	0.0000	0.0000	43.0000	3.0000	1.0000	0.0000
16	0.0000	0.0000	42.0000	8.0000	1.0000	0.0000
17	0.0000	0.0000	27.2000	9.8000	1.0000	0.0000
18	0.0000	0.0000	3.3000	0.6000	1.0000	0.0000
19	0.0000	0.0000	2.3000	1.0000	1.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
22	0.0000	0.0000	6.3000	2.1000	1.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
24	0.0000	0.0000	6.3000	3.2000	1.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
26	0.0000	0.0000	9.3000	0.5000	1.0000	0.0000
27	0.0000	0.0000	4.6000	2.3000	1.0000	0.0000
28	0.0000	0.0000	17.0000	2.6000	1.0000	0.0000
29	0.0000	0.0000	3.6000	1.8000	1.0000	0.0000
30	0.0000	0.0000	5.8000	2.9000	1.0000	0.0000
31	0.0000	0.0000	1.6000	0.8000	1.0000	0.0000
32	0.0000	0.0000	3.8000	1.9000	1.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
34	0.0000	0.0000	6.0000	3.0000	1.0000	0.0000
35	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000

34	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
35	0.0000	0.0000	14.0000	7.0000	1.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
39	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
40	0.0000	0.0000	6.3000	3.0000	1.0000	0.0000
41	0.0000	0.0000	7.1000	4.0000	1.0000	0.0000
42	0.0000	0.0000	2.0000	1.0000	1.0000	0.0000
43	0.0000	0.0000	12.0000	1.8000	1.0000	0.0000
44	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
45	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
46	0.0000	0.0000	29.7000	11.6000	1.0000	0.0000
47	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
48	0.0000	0.0000	18.0000	8.5000	1.0000	0.0000
49	0.0000	0.0000	21.0000	10.5000	1.0000	0.0000
50	0.0000	0.0000	18.0000	5.3000	1.0000	0.0000
51	0.0000	0.0000	4.9000	2.2000	1.0000	0.0000
52	0.0000	0.0000	20.0000	10.0000	1.0000	0.0000
53	0.0000	0.0000	4.1000	1.4000	1.0000	0.0000
54	0.0000	0.0000	6.8000	3.4000	1.0000	0.0000
55	0.0000	0.0000	7.6000	2.2000	1.0000	0.0000
56	0.0000	0.0000	6.7000	2.0000	1.0000	0.0000
57	0.0000	0.0000	55.0000	17.0000	1.0000	0.0000

LINE DATA

LINE NUMBER	FROM BUS	TO BUS	LINE IMPEDENCE		HALF LINE CHARG ADMIT		OFF NOM TR TURNS RATIO
1	57	1	0.00830	0.02800	0.00000	0.06450	1.00000
2	1	2	0.02980	0.08500	0.00000	0.04090	1.00000
3	2	3	0.01120	0.03660	0.00000	0.01900	1.00000
4	3	4	0.06250	0.13200	0.00000	0.01290	1.00000
5	3	5	0.04300	0.14800	0.00000	0.01740	1.00000
6	5	6	0.02000	0.10200	0.00000	0.01380	1.00000
7	5	7	0.03390	0.17300	0.00000	0.02350	1.00000
8	[illegible]	8	0.00990	0.05050	0.00000	0.02740	1.00000
9	6	9	0.03690	0.16970	0.00000	0.02200	1.00000
10	6	10	0.02580	0.08480	0.00000	0.01090	1.00000
11	8	11	0.06480	0.29500	0.00000	0.03860	1.00000
12	8	12	0.04810	0.15800	0.00000	0.02030	1.00000
13	12	13	0.01320	0.04340	0.00000	0.00550	1.00000
14	12	14	0.02690	0.08690	0.00000	0.01150	1.00000
15	57	14	0.01780	0.09100	0.00000	0.04940	1.00000
16	57	15	0.04540	0.20600	0.00000	0.02730	.00000
17	57	16	0.02380	0.10800	0.00000	0.01430	1.00000
18	2	14	0.01670	0.05300	0.00000	0.02720	1.00000
19	3	17	0.00000	0.55500	0.00000	0.00000	0.97000
20	3	17	0.00000	0.43000	0.00000	0.00000	0.97800

21	8	6	0.03020	0.06610	0.00000	0.02620	1.00000
22	5	7	0.01390	0.07120	0.00000	0.00970	1.00000
23	9	11	0.02770	0.12620	0.00000	0.01640	1.00000
24	10	12	0.02210	0.07320	0.00000	0.00940	1.00000
25	11	12	0.01780	0.05900	0.00000	0.03020	1.00000
26	11	15	0.01800	0.08130	0.00000	0.01080	1.00000
27	11	16	0.03970	0.17900	0.00000	0.02380	1.00000
28	13	14	0.01710	0.05470	0.00000	0.00740	1.00000
29	17	18	0.45100	0.68500	0.00000	0.00000	1.00000
30	18	19	0.28300	0.43400	0.00000	0.00000	1.00000
31	19	20	0.00000	0.77670	0.00000	0.00000	1.04300
32	20	21	0.07360	0.11700	0.00000	0.00000	1.00000
33	21	22	0.00990	0.01520	0.00000	0.00000	1.00000
34	22	23	0.16600	0.25600	0.00000	0.00420	1.00000
35	23	24	0.00000	1.18200	0.00000	0.00000	1.00000
36	23	24	0.00000	1.23000	0.00000	0.00000	1.00000
37	23	25	0.00000	0.04730	0.00000	0.00000	1.04300
38	25	26	0.16500	0.25400	0.00000	0.00000	1.00000
39	26	27	0.06180	0.09540	0.00000	0.00000	1.00000
40	27	28	0.04180	0.05670	0.00000	0.00000	1.00000
41	6	28	0.00000	0.06480	0.00000	0.00000	0.96700
42	24	29	0.13500	0.20200	0.00000	0.00000	1.00000
43	29	30	0.37600	0.49700	0.00000	0.00000	1.00000
44	30	31	0.50700	0.75500	0.00000	0.00000	1.00000
45	31	32	0.03920	0.03600	0.00000	0.00000	1.00000
46	31	33	0.00000	0.95300	0.00000	0.00000	1.00000
47	31	34	0.05200	0.07800	0.00000	0.00160	1.00000
48	34	35	0.04300	0.05370	0.00000	0.00080	1.00000
49	35	36	0.02900	0.03660	0.00000	0.00000	1.00000
50	35	37	0.06510	0.10090	0.00000	0.00100	1.00000
51	36	38	0.02390	0.03790	0.00000	0.00000	1.00000
52	45	39	0.03000	0.04660	0.00000	0.00000	1.00000
53	71	37	0.01920	0.02950	0.00000	0.00000	1.00000
54	10	40	0.00000	0.74900	0.00000	0.00000	0.95500
55	40	41	0.20700	0.35200	0.00000	0.00000	1.00000
56	40	42	0.00000	0.41200	0.00000	0.00000	1.00000
57	47	43	0.02890	0.05850	0.00000	0.00100	1.00000
58	16	44	0.00000	0.10420	0.00000	0.00000	0.95500
[illegible]	43	45	0.00000	0.07350	0.00000	0.00000	0.90000
[illegible]	45	46	0.02300	0.06800	0.00000	0.00160	1.00000
[illegible]	45	47	0.01820	0.02330	0.00000	0.00000	1.00000
[illegible]	47	48	0.08340	0.12900	0.00000	[illegible]	1.00000
[illegible]	[illegible]	[illegible]	0.08010	[illegible]	0.00000	0.00000	1.00000
[illegible]	[illegible]	[illegible]	0.13650	[illegible]	[illegible]	[illegible]	1.00000
[illegible]	[illegible]	[illegible]	0.00000	0.07120	0.00000	[illegible]	0.93000

LIST OF OUTPUT RESULTS

DMAX = 0.00015363 EPSIL = 0.00100000

NEWTON RAPHSON ITERATIVE TECHNIQUE CONVERGED IN 4 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1		1.01000	-1.18481	-0.00001	-0.46260	3.00000	88.00000
2		0.98474	-5.97006	40.00000	-4.62074	41.00000	21.00000
3		0.98173	-7.31889	-0.00002	-0.00059	0.00000	0.00000
4		0.97696	-8.52467	0.00001	-0.00051	13.00000	4.00000
5		0.98022	-8.65156	0.00008	0.05919	75.00000	2.00000
6		0.98454	-7.58478	-0.00004	0.01536	0.00000	0.00000
7		1.00500	-4.47147	450.00010	61.48202	150.00000	22.00000
8		0.98001	-9.59266	-0.00003	2.27571	121.00000	26.00000
9		0.98716	-11.47807	-0.00002	0.00157	5.00000	2.00000
10		0.97399	-10.20965	-0.00002	-0.00084	0.00000	0.00000
11		1.01500	-10.49009	310.00004	128.95345	377.00000	24.00000
12		0.97829	-9.82199	0.00002	0.00575	18.00000	2.30000
13		0.96943	-9.37825	-0.00001	0.00283	10.50000	5.30000
14		0.98785	-7.19780	0.00000	0.00336	22.00000	5.00000
15		1.01336	-8.87245	0.00000	0.00227	43.00000	3.00000
16		1.01744	-5.40293	0.00001	0.00334	42.00000	8.00000
17		1.01103	-11.50990	0.00004	-0.00159	27.20000	9.80000
18		1.00844	-13.36147	-0.00000	0.00043	3.30000	0.60000
19		1.01932	-13.81090	0.00001	-0.00065	2.30000	1.00000
20		1.00817	-12.83133	-0.00001	0.00037	0.00000	0.00000
21		1.01417	-12.84601	0.00006	0.00048	0.00000	0.00000
22		1.01258	-12.90917	0.00007	0.00005	6.30000	2.10000
23		1.00057	-13.23379	-0.00024	-0.00673	0.00000	0.00000
24		0.98029	-18.71654	0.00011	-0.00973	6.30000	3.20000
25		0.96167	-12.92784	0.00004	0.00232	0.00000	0.00000
26		0.98378	-11.47373	-0.00010	-0.00262	9.30000	0.50000
27		0.99866	-10.44832	-0.00003	0.00451	4.60000	2.30000
28		1.01204	-9.74209	0.00033	-0.00886	17.00000	2.60000
29		0.95894	-18.75776	0.00003	-0.00033	3.60000	1.80000
30		0.92865	-19.40950	0.00005	0.00068	5.80000	2.90000
31		0.93759	-18.48443	0.00009	-0.00278	1.60000	0.60000
32		0.93526	-18.52516	0.00002	0.00039	3.80000	1.90000
33		0.96703	-14.13720	-0.00009	-0.00437	0.00000	0.00000
34		0.97343	-13.89345	0.00002	-0.00018	6.00000	3.00000
35		0.98257	-13.62037	0.00000	0.00045	0.00000	0.00000
36		0.99139	-13.43294	0.00004	0.00035	0.00000	0.00000
37		1.01877	-12.72915	-0.00002	0.00128	14.00000	1.00000
38		0.98931	-13.47789	-0.00004	0.00006	0.00000	0.00000

39	0.97944	-13.64110	-0.00001	0.00025	0.00000	0.00000
40	1.00064	-14.04908	0.00006	-0.00197	6.30000	3.00000
41	0.97275	-15.53702	0.00001	0.00075	7.10000	4.00000
42	1.01221	-11.36190	-0.00003	-0.00319	2.00000	1.00000
43	1.02195	-11.84846	0.00004	0.00722	12.00000	1.80000
44	1.03941	-9.25738	0.00005	0.00310	0.00000	0.00000
45	1.07035	-11.17237	0.00005	-0.00073	0.00000	0.00000
46	1.04195	-12.55068	-0.00003	0.00030	29.70000	11.60000
47	1.03527	-12.63575	0.00004	0.00046	0.00000	0.00000
48	1.04528	-12.98777	0.00005	-0.00308	18.00000	8.50000
49	1.03190	-13.44176	-0.00002	-0.00117	21.00000	10.50000
50	1.05961	-12.55091	0.00003	-0.00432	18.00000	5.30000
51	0.98287	-11.47205	-0.00001	0.00326	4.90000	2.20000
52	0.97379	-12.22924	-0.00005	-0.00687	20.00000	10.00000
53	0.99978	-11.70240	0.00009	0.00234	4.10000	1.40000
54	1.03479	-10.81064	0.00010	0.00043	6.80000	3.40000
55	0.97476	-16.06116	0.00001	-0.00044	7.60000	2.20000
56	0.97146	-16.56956	0.00002	-0.00113	6.70000	2.00000
57	1.04000	0.00000	478.85788	129.09619	55.00000	17.00000

TOTAL GENERATION = 1278.858800 316.784490 TOTAL LOAD = 1250.800000 336.000000 TOTAL LOSSES = 28.058731 -19.215508

LIST OF OUTPUT RESULTS

DMAX = [illegible] EPSIL = [illegible]

[illegible] ITERATIVE TECHNIQUE CONVERGED IN 7 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1		1.01000	-1.18671	0.00004	-0.76004	2.00000	58.00000
2		0.98500	-5.98209	39.96127	-3.47973	41.00000	21.00000
3		0.98184	-7.32915	-0.00089	0.02224	0.00000	0.00000
4		0.97	-8.52873	0.12587	-0.12585	13.00000	4.00000
		0.98000	-8.55974	-0.11965	-0.28888	75.00000	2.00000
		0.98426	-7.59294	0.05934	-0.05026	[illegible].00000	0.00000
		1.00500	-4.48458	449.98062	62.03233	1[illegible]0.00000	22.00000
		0.[illegible]000	-9.60798	-0.03457	0.41437	121.00000	26.00000
		0.[illegible]8717	-11.49198	0.01648	0.02017	5.00000	2.00000
10		0.97400	-10.22518	0.04485	0.07313	0.00000	0.00000
11		1.01500	-10.50116	309.97891	128.94083	377.00000	24.00000
12		0.97829	-9.83467	0.01370	0.03735	18.00000	2.10000
13		0.96942	-9.39125	-0.03770	0.02910	10.50000	5.20000
14		0.98789	-7.20522	0.10484	-0.11909	22.00000	5.00000
15		1.01337	-8.82071	-0.00486	0.02594	43.00000	3.00000
16		1.01745	-5.40742	-0.00482	0.02982	42.00000	8.00000
17		1.01111	-11.52153	-0.07257	0.18052	27.[illegible]0000	9.80000
18		1.00740	-13.30184	0.04749	-0.23038	3.30000	0.60000
19		1.01843	-13.75405	0.02052	0.03537	2.30000	1.00000
20		1.00727	-12.77770	0.02106	-0.08355	0.00000	0.00000
21		1.01334	-12.79757	0.02496	-0.04571	0.00000	0.00000
22		1.01164	-12.65765	0.09955	-0.19494	6.30000	2.10000
23		0.99814	-13.16193	-0.09321	-0.40311	0.00000	0.00000
24		0.97785	-18.18733	-0.36132	0.14570	6.30000	3.20000
25		0.95930	-12.85486	0.01472	-0.11799	0.00000	0.00000
26		0.98154	-11.40300	0.00525	-0.44812	9.30000	0.50000
27		0.99692	-10.39319	0.33951	-1.80667	4.60[illegible]	2.30000
28		1.01150	-9.75253	-1.28227	5.11822	17.00000	2.60000
29		0.95664	-18.68350	0.19419	-0.09129	3.50000	1.80000
30		0.92651	-19.29646	0.04032	0.00124	5.80000	2.90000
31		0.93560	-18.32196	-3.40881	4.81658	1.60000	0.80000
32		0.93284	-18.15889	3.38746	-4.81547	3.80000	1.90000
33		0.96499	-13.89255	0.08681	0.01097	0.00000	0.00000
34		0.97140	-13.6[illegible]34	1.10395	-1.59369	6.00000	3.00000
35		0.98094	-13.44805	0.46798	-0.40198	0.00000	0.00000
36		0.99013	-13.33055	-1.19780	1.54550	0.00000	0.00000
37		1.01817	-12.68891	0.35124	0.11428	14.00000	7.00000
38		0.98796	-13.36780	0.12693	-0.30876	0.00000	0.00000

39	0.97771	-13.46570	-0.02680	-0.16573	0.00000	0.00000
40	1.00061	-14.08403	-0.54410	1.04472	6.30000	3.00000
41	0.97140	-15.44698	0.10193	-0.18261	7.10000	4.00000
42	1.01222	-11.38254	0.00306	0.00671	2.00000	1.00000
43	1.02145	-11.81704	0.11250	-0.25136	12.00000	1.80000
44	1.03931	-9.26118	-0.24404	0.32743	0.00000	0.00000
45	1.07028	-11.19151	0.00679	-0.03116	0.00000	0.00000
46	1.04183	-12.57561	-1.87876	1.96959	29.70000	11.60000
47	1.03500	-12.62024	1.61676	-1.43353	0.00000	0.00000
48	1.04524	-13.00571	-1.02992	1.21992	18.00000	8.50000
49	1.03176	-13.41394	0.67834	-0.59136	21.00000	10.50000
50	1.05962	-12.56618	-0.27616	0.21357	18.00000	5.30000
51	0.97756	-11.12921	0.69989	-1.95758	4.90000	2.20000
52	0.96733	-11.82723	0.44883	-2.48429	20.00000	10.00000
53	0.99614	-11.47821	0.30894	-0.53375	4.10000	1.40000
54	1.03457	-10.83320	-0.62445	1.75323	6.80000	3.40000
55	0.97252	-15.88570	0.47178	-1.24152	7.60000	2.20000
56	0.96982	-16.45198	-0.11613	0.30738	6.70000	2.00000
57	1.04000	0.00000	479.25882	128.98084	55.00000	17.00000

TOTAL GENERATION = 1278.941700 317.174700 TOTAL LOAD = 1250.800000 336.000000 TOTAL LOSSES = 28.141647 -18.825302

LIST OF OUTPUT RESULTS

DMAX = 0.01986371 EPSIL = 0.02000000

FAST DECOUPLED ITERATIVE TECHNIQUE CONVERGED IN 6 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1		1.01000	-1.18446	0.00167	-0.76866	3.00000	98.00000
2		0.98500	-5.97264	40.00375	-3.67385	41.00000	21.00000
3		0.98185	-7.31812	0.00034	-0.00674	0.00000	0.00000
4		0.97685	-8.51885	-0.00328	0.00741	13.00000	4.00000
5		0.98000	-8.64321	0.00345	-0.60557	75.00000	2.00000
6		0.98446	-7.57707	-0.01122	-0.01568	0.00000	0.00000
7		1.00500	-4.46509	450.00189	61.74142	150.00000	22.00000
8		0.98000	-9.58682	-0.01836	2.17740	121.00000	26.00000
9		0.98717	-11.47347	-0.00064	-0.00264	5.00000	2.00000
10		0.97402	-10.20420	0.01632	-0.04342	0.00000	0.00000
11		1.01500	-10.48647	309.99691	128.88437	377.00000	24.00000
12		0.97833	-9.81855	-0.00626	0.00310	18.00000	2.30000
13		0.96951	-9.37543	0.00440	-0.02650	10.50000	5.30000
14		0.98796	-7.19713	-0.01849	0.01748	22.00000	5.00000
15		1.01336	-8.86984	0.00035	-0.00766	43.00000	3.00000
16		1.01744	-5.40153	0.00086	-0.00794	42.00000	8.00000
17		1.01116	-11.50769	0.04616	-0.06509	27.20000	9.80000
18		1.00835	-13.37454	-0.04539	0.07089	3.30000	0.60000
19		1.01922	-13.82265	0.00600	-0.00627	2.30000	1.00000
20		1.00805	-12.84395	-0.01326	0.02079	0.00000	0.00000
21		1.01405	-12.85776	-0.01924	0.02441	0.00000	0.00000
22		1.01245	-12.92208	-0.07316	0.11416	6.30000	2.10000
23		1.00029	-13.25571	-0.08274	0.10393	0.00000	0.00000
24		0.98009	-18.23131	0.02498	-0.02716	6.30000	3.20000
25		0.96139	-12.94996	-0.00527	0.03353	0.00000	0.00000
26		0.98341	-11.49338	-0.09168	0.16650	9.30000	0.50000
27		0.99833	-10.46159	-0.54233	0.72537	4.60000	2.30000
28		1.01196	-9.73343	1.49961	-2.01020	17.00000	2.60000
29		0.95875	-18.77251	0.00079	0.00767	3.60000	1.80000
30		0.92845	-19.42388	0.02922	-0.03303	5.80000	2.90000
31		0.93722	-18.51168	1.59849	-1.55546	1.60000	0.80000
32		0.93423	-16.59008	-1.59366	1.56858	3.80000	1.90000
33		0.96658	-14.17672	0.04520	-0.05349	0.00000	0.00000
34		0.97293	-13.93576	-0.39711	0.54307	6.00000	3.00000
35		0.98221	-13.65156	-0.10078	0.10186	0.00000	0.00000
36		0.99118	-13.45345	0.37285	-0.46772	0.00000	0.00000
37		1.01869	-12.73814	0.02471	-0.03456	14.00000	7.00000
38		0.98908	-13.50014	-0.08371	0.12076	0.00000	0.00000

39	0.97906	-13.67371	-0.05486	0.06831	0.00000	0.00000
40	1.00072	-14.03850	0.25818	-0.37128	6.30000	3.00000
41	0.97256	-15.54872	-0.00356	0.01179	7.10000	4.00000
42	1.01226	-11.35499	0.00169	-0.00339	2.00000	1.00000
43	1.02191	-11.85522	-0.03916	0.06849	12.00000	1.80000
44	1.03948	-9.25728	0.10746	-0.15032	0.00000	0.00000
45	1.07044	-11.16822	-0.00910	0.01407	0.00000	0.00000
46	1.04206	-12.54501	0.89530	-1.10641	29.70000	11.60000
47	1.03523	-12.64071	-0.82498	0.96466	0.00000	0.00000
48	1.04533	-12.98450	0.37004	-0.52021	18.00000	8.50000
49	1.03184	-13.44680	-0.20425	0.30501	21.00000	10.50000
50	1.05963	-12.54611	0.08378	-0.12007	18.00000	5.30000
51	0.98160	-11.55144	-0.41927	0.53051	4.90000	2.20000
52	0.97222	-12.33150	-0.60885	0.93328	20.00000	10.00000
53	0.99873	-11.76736	-0.29828	0.37501	4.10000	1.40000
54	1.03476	-10.80322	0.61255	-0.77547	6.80000	3.40000
55	0.97431	-16.09467	-0.29956	0.45135	7.60000	2.20000
56	0.97116	-16.59074	0.08707	-0.10455	6.70000	2.00000
57	1.04000	0.00000	478.76959	128.98431	55.00000	17.00000

TOTAL GENERATION = 1278.995100 316.576160 TOTAL LOAD = 1250.800000 336.000000 TOTAL LOSSES = 28.195084 -19.423843

HYDRO POWER EVACUATION FOR APRIL 1982.

IPDATA = 0 ISHIFT = 1 INETH = 3 ICHOIC = 0 ISTART = 0

NO. OF STUDIES = 1 PRINT OPTIONS = 2 2 2 2 2 2

LIST OF INPUT DATA

NO. OF BUSES	NO. OF LINES	SLACK BUS	VOLT. CONT BUSES	SHUNT LOADS	MAX. ITERATIONS	CONV. LIMIT	BASE POWER
100	128	1	[illegible]	37	10	.00100000	100.[illegible]

BUS DATA

BUS NO.	NAME	GENERATION		LOAD POWER		ASSUMED BUS VOLTAGES VOLT MAG	PHASE ANGLE
1	OBRA(TH)10.5	136.0000	90.0000	0.0000	0.0000	1.0000	0.0000
2	OBRA(TH)220	0.0000	0.0000	58.2000	40.0000	1.0000	0.0000
3	OBRA A 15.75	398.0000	175.0000	0.0000	0.0000	1.0000	0.0000
4	OBRA'A'420	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
5	PANKI 11	24.0000	20.0000	0.0000	0.0000	1.0000	0.0000
6	PANKI 132	0.0000	0.0000	80.0000	60.0000	1.0000	0.0000
7	PANKI(EXT)11	140.0000	90.0000	0.0000	0.0000	1.0000	0.0000
8	PANKI 220	0.0000	0.0000	55.0000	34.5000	1.0000	0.0000
9	PANKI 400	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
10	HDJ'A' 11	22.0000	10.0000	0.0000	0.0000	1.0000	0.0000
11	HDJ 132	0.0000	0.0000	110.0000	90.0000	1.0000	0.0000
12	HDJ'B' 11	50.0000	40.0000	0.0000	0.0000	1.0000	0.0000
13	HDJ 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
14	RIHAND 11	40.0000	30.0000	0.0000	0.0000	1.0000	0.0000
15	RIHAND 132	0.0000	0.0000	73.0000	58.0000	1.0000	0.0000
16	OBRA(H) 11	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
17	OBRA(H)132	0.0000	0.0000	18.0000	10.5000	1.0000	0.0000
18	KHATIMA 11	25.0000	15.0000	0.0000	0.0000	1.0000	0.0000
19	KHATIMA132	0.0000	0.0000	9.6000	8.0000	1.0000	0.0000
20	CHILLA 11	131.0000	90.0000	0.0000	0.0000	1.0000	0.0000
21	CHILLA 132	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
22	RAMGANGA 11	48.0000	30.0000	0.0000	0.0000	1.0000	0.0000
23	RAMGANGA132	0.0000	0.0000	2.5000	1.2000	1.0000	0.0000
24	CHIBRO 11	120.0000	55.0000	0.0000	0.0000	1.0000	0.0000
25	CHIBRO 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
26	DAKRANI 11	33.0000	20.0000	0.0000	0.0000	1.0000	0.0000
27	DAKRANI 132	0.0000	0.0000	2.5000	1.0000	1.0000	0.0000
28	DHALIPUR 11	51.0000	20.0000	0.0000	0.0000	1.0000	0.0000
29	DHALIPUR132	0.0000	0.0000	2.5000	1.0000	1.0000	0.0000
30	KULHAL 11	80.0000	50.0000	0.0000	0.0000	1.0000	0.0000
31	KULHAL 132	0.0000	0.0000	2.5000	1.0000	1.0000	0.0000
32	ROBGANG 132	0.0000	0.0000	18.0000	13.5000	1.0000	0.0000
33	SAHUPURI132	0.0000	0.0000	50.0000	42.0000	1.0000	0.0000
34	SAHUPURI 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
35	GAJIPUR 132	0.0000	5.0000	12.0000	7.2000	1.0000	0.0000

36 MAU 132	0.0000	0.0000	13.2000	10.0000	1.0000	0.0000
37 GKP 132	0.0000	0.0000	32.0000	35.0000	1.0000	0.0000
38 GKP 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
39 KHALBAD 132	0.0000	0.0000	9.6000	6.0000	1.0000	0.0000
40 BASTI 62	0.0000	0.0000	9.6000	6.0000	1.0000	0.0000
41 FZD 132	0.0000	0.0000	16.0000	16.0000	1.0000	0.0000
42 MANDADIH132	0.0000	0.0000	22.0000	20.0000	1.0000	0.0000
43 JAUNPUR 152	0.0000	0.0000	15.0000	12.0000	1.0000	0.0000
44 MIRZAPUR152	0.0000	0.0000	8.0000	5.0000	1.0000	0.0000
45 JIGNA 132	0.0000	0.0000	8.0000	6.0000	1.0000	0.0000
46 SLN 132	0.0000	0.0000	58.0000	50.5800	1.0000	0.0000
47 SLN 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
48 SLN'A' 400	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
49 ALLD 132	0.0000	0.0000	34.0000	34.0000	1.0000	0.0000
50 ALLD 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
51 LUCKNOW132	0.0000	0.0000	50.0000	31.0000	1.0000	0.0000
52 LUCKNOW220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
53 LUCKNOW400	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
54 SITAPUR182	0.0000	0.0000	28.0000	18.0000	1.0000	0.0000
55 SITAPUR220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
56 SHAJPUR132	0.0000	0.0000	22.0000	13.5000	1.0000	0.0000
57 SHAHPUR220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
58 DHUNA 132	0.0000	0.0000	32.0000	31.0000	1.0000	0.0000
59 KHURJA 132	0.0000	0.0000	20.0000	17.0000	1.0000	0.0000
60 KHURJA 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
61 BHOOR 132	0.0000	0.0000	0.0000	25.0000	1.0000	0.0000
62 MURAD 132	0.0000	0.0000	60.0000	48.0000	1.0000	0.0000
63 MURAD 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
64 MURAD 400	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
65 MEERUT132	0.0000	0.0000	40.0000	40.0000	1.0000	0.0000
66 MEERUT220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
67 SHAMLI220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
68 SAHAPUR132	0.0000	0.0000	18.0000	18.0000	1.0000	0.0000
69 SAHAPUR220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
70 ROORKEE 52	0.0000	0.0000	6.0000	5.0000	1.0000	0.0000
71 HARDWAR132	0.0000	0.0000	18.0000	16.0000	1.0000	0.0000
72 RISH 132	0.0000	0.0000	22.0000	17.0000	1.0000	0.0000
73 RISH 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
74 DDN 132	0.0000	0.0000	13.0000	10.0000	1.0000	0.0000
75 KHODRI 132	0.0000	0.0000	2.5000	1.0000	1.0000	0.0000
76 KHODRI 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
77 NEHTAUR132	0.0000	0.0000	20.0000	24.0000	1.0000	0.0000
78 KASHPUR132	0.0000	0.0000	5.0000	3.0000	1.0000	0.0000
79 MBD 132	0.0000	0.0000	36.0000	36.0000	1.0000	0.0000
80 MBD 220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000

81 GAJRALA 72	0.0000	0.0000	9.0000	7.0000	1.0000	0.0000
82 HAPUR 132	0.0000	0.0000	18.0000	18.0000	1.0000	0.0000
83 SHAGANJ132	0.0000	0.0000	5.0000	4.0000	1.0000	0.0000
84 HALDWANI132	0.0000	0.0000	8.0000	6.0000	1.0000	0.0000
85 MAINPURI220	0.0000	0.0000	55.0000	48.0000	1.0000	0.0000
86 MUZAFFR220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
87 MUZAFFR132	0.0000	0.0000	32.0000	30.0000	1.0000	0.0000
88 AZAM220	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
89 AZAM132	0.0000	0.0000	10.0000	7.5000	1.0000	0.0000
90 SHAMLI132	0.0000	0.0000	15.0000	12.0000	1.0000	0.0000
91 OBRA'B'15.75	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
92 OBRA'B'420	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
93 SLN'B' 400	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
94 OBRA'A' 33	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
95 OBRA'B' 33	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
96 SLN 'A' 33	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
97 SLN 'B' 33	0.0000	0. 000	0.0000	0.0000	1.0000	0.0000
98 PANKI 33	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
99 LKO 33	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
100 MURAD 33	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000

LINE DATA

LINE NUMBER	FROM BUS	TO BUS	LINE IMPEDENCE		HALF LINE CHARG ADMIT		OFF NOM TR TURNS RATIO
1	4 OBRA'A'420	9 PANKI 400	0.00790	0.08120	0.00000	0.26500	1.00000
2	9 PANKI 400	64 MURAD 400	0.00796	0.08112	0.00000	0.25500	1.00000
3	48 SLN'A' 400	53 LUCKNOW400	0.00298	0.03009	0.00000	0.09820	1.00000
4	48 SLN'A' 400	4 OBRA'A'420	0.00496	0.04775	0.00000	0.05013	1.00000
5	63 MURAD 220	64 MURAD 400	0.00000	0.02604	0.00000	0.00000	1.02500
6	2 OBRA(TH)220	34 SAHUPURI 220	0.00811	0.03877	0.00000	0.13220	1.00000
7	2 OBRA(TH)220	50 ALLD 220	0.01000	0.02370	0.00000	0.07200	1.00000
8	38 GKP 220	47 SLN 220	0.02470	0.10685	0.00000	0.10120	1.00000
9	50 ALLD 220	8 PANKI 220	0.01722	0.08229	0.00000	0.28059	1.00000
10	8 PANKI 220	52 LUCKNOW220	0.00505	0.02413	0.00000	0.08229	1.00000
11	8 PANKI 220	85 MAINPURI220	0.01292	0.06171	0.00000	0.21043	1.00000
12	85 MAINPURI220	13 HDJ 220	0.01060	0.05064	0.00000	0.17265	1.00000
13	60 KHURJA 220	63 MURAD 220	0.00497	0.02374	0.00000	0.08093	1.00000
14	13 HDJ 220	60 KHURJA 220	0.00373	0.01780	0.00000	0.06870	1.00000
15	63 MURAD 220	67 SHAMLI220	0.01739	0.08307	0.00000	0.07932	1.00000
16	13 HDJ 220	80 MBD 220	0.01845	0.09395	0.00000	0.07400	1.00000
17	73 RISH 220	86 MUZAFFR220	0.01390	0.06997	0.00000	0.05690	1.00000
18	63 MURAD 220	66 MEERUT220	0.00761	0.03832	0.00000	0.03120	1.00000
19	69 SAHAPUR220	67 SHAMLI220	0.01150	0.05790	0.00000	0.04711	1.00000
20	69 SAHAPUR220	76 KHODRI 220	0.00720	0.03442	0.00000	0.11720	1.00000
21	66 MEERUT220	86 MUZAFFR220	0.00993	0.04998	0.00000	0.04067	1.00000
22	73 RISH 220	76 KHODRI 220	0.01440	0.07247	0.00000	0.05898	1.00000

23	75 KHODRI 220	25 CHIPRO 220	0.00021	0.00099	0.00000	0.00337	1.00000
24	52 LUCKNOW220	55 SITAPUR220	0.01589	0.07997	0.00000	0.06508	1.00000
25	2 OBRA(TH)220	17 OBRA(H)132	0.00056	0.04133	0.00000	0.00061	1.00000
26	17 OBRA(H)132	15 RIHAND 132	0.01582	0.03767	0.00000	0.01735	1.00000
27	15 RIHAND 132	32 ROBGANG 132	0.0260	0.06205	0.00000	0.02849	1.00000
28	17 OBRA(H)132	32 ROBGANG 132	0.01303	0.03102	0.00000	0.01429	1.00000
29	32 ROBGANG 132	33 SAHUPURI132	0.04048	0.09640	0.00000	0.04439	1.00000
30	32 ROBGANG 132	44 MIRZAPUR152	0.04680	0.11760	0.00000	0.01860	1.00000
31	33 SAHUPURI132	35 GAJIPUR 132	0.05100	0.13100	0.00000	0.01220	1.00000
32	33 SAHUPURI132	36 MAU 132	0.09120	0.21717	0.00000	0.02500	1.00000
33	33 SAHUPURI132	42 NANDADIH132	0.05000	0.12500	0.00000	0.05200	1.000..
34	35 GAJIPUR 132	36 MAU 132	0.04080	0.10480	0.00000	0.00980	1.00000
35	37 GKP 132	36 MAU 132	0.04932	0.11745	0.00000	0.05408	1.00000
36	37 GKP 132	39 KHALBAD 132	0.03400	0.08750	0.00000	0.00900	1.00000
37	39 KHALBAD 132	40 BASTI 62	0.02559	0.06550	0.00000	0.00620	1.00000
38	41 FZD 132	46 SLN 132	0.05491	0.13822	0.00000	0.01420	1.00000
39	42 NANDADIH132	43 JAUNPUR 152	0.05000	0.13500	0.00000	0.01360	1.00000
40	44 MIRZAPUR152	45 JIGNA 132	0.01700	0.03950	0.00000	0.01800	1.00000
41	51 LUCKNOW132	54 SITAPUR182	0.08004	0.20147	0.00000	0.02072	1.00000
42	54 SITAPUR182	56 SHAJPUR132	0.08560	0.21550	0.00000	0.02216	1.00000
43	56 SHAJPUR132	58 DHONA 132	0.03816	0.09086	0.00000	0.04184	1.00000
44	58 DHONA 132	19 KHATIMA132	0.03908	0.09307	0.00000	0.04286	1.00000
45	2 OBRA(TH)220	15 RIHAND 132	0.03258	0.18200	0.00000	0.00843	1.00000
46	59 KHURJA 132	61 BHOOR 132	0.01945	0.04955	0.00000	0.00500	1.00000
47	61 BHOOR 132	62 MURAD 132	0.05100	0.13600	0.00000	0.01390	1.00000
48	70 ROORKEE 52	68 SAHAPUR132	0.01442	0.03435	0.00000	0.01582	1.00000
49	70 ROORKEE 52	71 HARDWAR132	0.01580	0.03767	0.00000	0.01735	1.00000
50	77 NEHTAUR132	70 ROORKEE 52	0.04048	0.09640	0.00000	0.04439	1.00000
51	71 HARDWAR132	72 RISH 132	0.02233	0.05318	0.00000	0.00612	1.00000
52	74 DDN 132	31 KULHAL 132	0.04860	0.10000	0..000	0.00900	1.00000
53	72 RISH 132	74 DDN 132	0.01861	0.04432	0.00000	0.02040	1.00000
54	74 DDN 132	29 DHALIPUR132	0.03860	0.09880	0.00000	0.00900	1.00000
55	31 KULHAL 132	29 DHALIPUR132	0.00450	.01100	0.00000	0.00120	1.00000
56	29 DHALIPUR132	27 DAKRANI 132	0.00450	0.01100	0.00000	0.00120	1.00000
57	27 DAKRANI 132	75 KHODRI 132	0.00450	0.01100	0.00000	0.00120	1.00000
58	77 NEHTAUR132	23 RAMGANGA132	0.02699	0.06426	0.00000	0.02960	1.00000
59	79 MBD 132	77 NEHTAUR132	0.01603	0.03878	0.00000	0.07000	1.00000
60	23 RAMGANGA132	78 KASHPUR132	0.02280	0.05430	0.00000	0.02500	1.00000
61	79 MBD 132	81 GAJRALA 72	0.04600	0.11530	0.00000	0.01220	1.00000
62	78 KASHPUR132	79 MBD 132	0.05677	0.14300	0.00000	0.01470	1.00000
63	81 GAJRALA 72	82 HAPUR 132	0.04700	0.11650	0.00000	0.01340	1.00000
64	11 HOJ 132	59 KHURJA 132	0.04188	0.10542	0.00000	0.01084	1.00000
65	43 JAUNPUR 152	83 SHAGANJ132	0.04010	0.10075	0.00000	0.01040	1.00000
66	84 HALDWANI132	78 KASHPUR132	0.05398	0.13588	0.00000	0.01397	1.00000

67	21 CHILLA 132	72 RISH 132	0.01396	0.03514	0.00000	0.00361	1.00000
68	7 HARDWAR132	21 CHILLA 132	0.00331	0.02216	0.00000	0.00250	1.00000
69	77 NEHTAUR132	21 CHILLA 132	0.08097	0.20382	0.00000	0.02096	1.00000
70	58 DHONA 132	79 MBD 132	0.04141	0.09861	0.00000	0.04541	1.00000
71	14 KIHAND 11	15 KIHAND 132	0.00000	0.03400	0.00000	0.00000	0.95000
72	16 OBRA(H) 11	17 OBRA(H)132	0.00000	0.16650	0.00000	0.00000	0.95000
73	1 OBRA(TH)10.5	2 OBRA(TH)220	0.00000	0.02430	0.00000	0.00000	0.95000
74	3 OBRA A 15.75	4 OBRA'A'420	0.00000	0.02010	0.00000	0.00000	1.00000
75	2 OBRA(TH)220	4 OBRA'A'420	0.00000	0.02508	0.00000	0.00000	1.05000
76	18 KHATIMA 11	19 KHATIMA132	0.00000	0.29550	0.00000	0.00000	1.00000
77	7 PANKI(EXT)11	8 PANKI 220	0.00000	0.07971	0.00000	0.00000	1.00000
78	6 PANKI 132	8 PANKI 220	0.00000	0.05000	0.00000	0.00000	1.00000
79	8 PANKI 220	9 PANKI 400	0.00000	0.05208	0.00000	0.00000	1.00000
80	5 PANKI 11	6 PANKI 132	0.00000	0.27500	0.00000	0.00000	1.00000
81	10 HDJ'A' 11	11 HDJ 132	0.00000	0.14625	0.00000	0.00000	0.95000
82	12 HDJ'B' 11	13 HDJ 220	0.00000	0.05225	0.00000	0.00000	0.95000
83	11 HDJ 132	13 HDJ 220	0.00000	0.03884	0.00000	0.00000	1.00000
84	30 KULHAL 11	31 KULHAL 132	0.00000	0.30000	0.00000	0.00000	1.00000
85	28 DHALIPUR 11	29 DHALIPUR132	0.00000	0.30000	0.00000	0.00000	1.00000
86	26 DAKRANI 11	27 DAKRANI 132	0.00000	0.50000	0.00000	0.00000	1.00000
87	24 CHIBRO 11	25 CHIBRO 220	0.00000	0.09420	0.00000	0.00000	1.00000
88	22 RAMGANGA 11	23 RAMGANGA132	0.00000	0.07500	0.00000	0.00000	0.95000
89	20 CHILLA 11	21 CHILLA 132	0.00000	0.[illegible]500	0.00000	0.00000	0.95000
90	33 SAHUPUR1132	34 SAHUPURI 220	0.00000	0.04660	0.00000	0.00000	1.00000
91	37 GKP 132	38 GKP 220	0.00000	0.05000	0.00000	0.00000	1.00000
92	46 SLN 132	47 SLN 220	0.00000	0.05000	0.00000	0.00000	1.00000
93	47 SLN 220	48 SLN'A' 400	0.00000	0.05208	0.00000	0.00000	1.07500
94	49 ALLD 132	50 ALLD 220	0.00000	0.08000	0.00000	0.00000	1.05000
95	51 LUCKNOW132	52 LUCKNOW220	0.00000	0.04900	0.00000	0.00000	1.00000
96	52 LUCKNOW220	53 LUCKNOW400	0.00000	0.06000	0.00000	0.00000	0.95000
97	59 KHURJA 132	60 KHURJA 220	0.[illegible]000	0.10000	0.00000	0.00000	1.02500
98	62 MURAD 132	63 MURAD 220	0.00000	0.05000	0.00000	0.00000	1.05000
99	65 MEERUT132	66 MEERUT220	0.00000	0.04640	0.00000	0.00000	1.00000
100	68 SAHAPUR132	69 SAHAPUR220	0.00000	0.05088	0.00000	0.00000	1.05000
101	72 RISH 132	73 RISH 220	0.00000	0.10320	0.00000	0.00000	0.98000
102	75 KHODRI 132	76 KHODRI 220	0.00000	0.10000	0.00000	0.00000	1.00000
103	79 MBD 132	80 MBD 220	0.00000	0.05000	0.00000	0.00000	1.05000
104	54 SITAPUR182	55 SITAPUR220	0.00000	0.10000	0.00000	0.00000	1.00000
105	56 SHAJPUR132	57 SHAHPUR220	0.00000	0.10000	0.00000	0.00000	1.00000
106	89 AZAM132	88 AZAM220	0.00000	0.10000	0.00000	0.00000	1.00000
107	90 SHAMLI132	67 SHAMLI220	0.00000	0.05000	0.00000	0.00000	1.00000
108	87 MUZAFFR132	86 MUZAFFR220	0.00000	0.05000	0.00000	0.00000	1.00000
109	34 SAHUPURI 220	88 AZAM220	0.01738	0.08747	0.00000	0.07117	1.00000
110	89 AZAM132	36 MAU 132	0.02547	0.04875	0.00000	0.02245	0.95000
111	90 SHAMLI132	87 MUZAFFR132	0.04561	0.11479	0.00000	0.01181	1.00000

112	91 OBRA'B'15.75	92 OBRA'B'420	0.00000	0.02915	0.00000	0.00000	1.00000
113	2 OBRA(TH)220	92 OBRA'B'420	0.00000	0.05208	0.00000	0.00000	1.05000
114	47 SLN 20	93 SLN'B' 400	0.00000	0.05208	0.00000	0.00000	1.07500
115	94 OBRA'A' 33	4 OBRA'A'420	0.00000	0.33833	0.00000	0.00000	1.00000
116	94 OBRA'A' 33	2 OBRA(TH)220	0.00000	0.28666	0.00000	0.00000	1.00000
117	95 OBRA'B' 33	92 OBRA'B'420	0.00000	0.33833	0.00000	0.00000	1.00000
118	95 OBRA'B' 33	2 OBRA(TH)220	0.00000	0.28666	0.00000	0.00000	1.00000
119	96 SLN 'A' 33	48 SLN'A' 400	0.00000	0.33833	0.00000	0.00000	1.00000
120	96 SLN 'A' 33	47 SLN 220	0.00000	0.28666	0.00000	0.00000	1.00000
121	97 SLN 'B' 33	93 SLN'B' 400	0.00000	0.33833	0.00000	0.00000	1.00000
122	97 SLN 'B' 33	47 SLN 220	0.00000	0.28666	0.00000	0.00000	1.00000
123	98 PANKI 33	9 PANKI 400	0.00000	0.16917	0.00000	0.00000	1.00000
124	98 PANKI 33	8 PANKI 220	0.00000	0.14333	0.00000	0.00000	1.00000
125	99 LKO 33	53 LUCKNOW400	0.00000	0.16917	0.00000	0.00000	1.00000
126	99 LKO 33	52 LUCKNOW220	0.00000	0.14333	0.00000	0.00000	1.00000
127	100 MURAD 33	64 MURAD 400	0.00000	0.16917	0.00000	0.00000	1.00000
128	100 MURAD 33	63 MURAD 220	0.00000	0.14333	0.00000	0.00000	1.00000

VOLTAGE CONTROLLED BUS DATA

S.NO.	BUS NO. NAME	Q-MINIMUM	Q-MAXIMUM	SCHEDULED VOLTAGE
1	3 OBRA A 15.75	-15.0000	150.0000	1.0100
2	5 PANKI 11	-3.2000	22.0000	1.0100
3	34 SAHUPURI 220	-20.0000	20.0000	1.0300
4	12 HDJ'B' 11	-16.5000	40.0000	0.9800
5	1 OBRA(TH)10.5	-35.0000	90.0000	1.0000
6	18 KHATIMA 11	-2.7600	15.0000	1.0500
7	20 CHILLA 11	-7.2000	90.0000	1.0500
8	24 CHIBRO 11	-12.0000	60.0000	1.0400
9	28 DHALIPUR 11	-1.7000	20.0000	1.0400
10	73 RISH 220	0.0000	20.0000	1.0500
11	62 MURAD 132	0.0000	50.0000	1.0500
12	7 PANKI(EXT)11	0.0000	90.0000	1.0200
13	10 HDJ'A' 11	0.0000	10.0000	0.9800
14	14 RIHAND 11	0.0000	30.0000	0.9800
15	22 RAMGANGA 11	0.0000	30.0000	1.0200
16	26 DAKRANI 11	0.0000	20.0000	1.0500
17	30 KULHAL 11	0.0000	50.0000	1.0500
18	46 SLN 132	-20.0000	30.0000	1.0200
19	85 MAINPURI220	0.0000	50.0000	1.0100

SHUNT LOAD DATA

S.NO.	BUS NO. NAME	SHUNT LOAD AVAILABLE	
1	31 ROBGANG 132	0.00000	0.05400
2	33 SAHUPURI132	0.00000	0.13800
3	36 MAU 132	0.00000	0.09500
4	37 GKP 132	0.00000	0.38600

5	41	FZD 132	0.00000	0.12100
6	46	SLN 132	0.00000	0.05600
7	49	ALLD 132	0.00000	0.08900
8	51	LUCKNOW132	0.00000	0.07400
9	54	SITAPUR182	0.00000	0.04400
10	56	SHAJPUR132	0.00000	0.02400
11	58	DHONA 132	0.00000	0.09900
12	6	PANKI 132	0.00000	0.08300
13	11	HDJ 132	0.00000	0.40300
14	59	KHURJA 132	0.00000	0.22900
15	62	MURAD 132	0.00000	0.20000
16	65	MEERUT132	0.00000	0.10100
17	90	SHAMLI132	0.00000	0.18700
18	70	ROORKEE 52	0.00000	0.06900
19	78	KASHPUR132	0.00000	0.03100
20	79	MBD 132	0.00000	0.42600
21	85	MAINPURI220	0.00000	0.07000
22	87	MUZAFFR132	0.00000	0.35000
23	4	OBRA'A'420	0.00000	-1.00000
24	9	PANKI 400	0.00000	-1.00000
25	48	SLN'A' 400	0.00000	-0.50000
26	53	LUCKNOW400	0.00000	-0.50000
27	64	MURAD 400	0.00000	-0.50000
28	89	AZAM132	0.00000	0.04500
29	92	OBRA'B'420	0.00000	0.00000
30	40	BASTI 62	0.00000	0.05000
31	68	SAHAPUR132	0.00000	0.12000
32	94	OBRA'A' 33	0.00000	0.00000
33	96	SLN 'A' 33	0.00000	0.00000
34	77	NEHTAUR132	0.00000	0.08800
35	98	PANKI 33	0.00000	0.00000
36	99	LKO 33	0.00000	0.00000
37	100	MURAD 33	0.00000	0.00000

LIST OF OUTPUT RESULTS

DMAX = 0.00015998 EPSIL = 0.00100000

NEWTON RAPHSON ITERATIVE TECHNIQUE CONVERGED IN 7 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1	OBRA(TH)10.5	1.00000	0.00000	129.39452	103.62430	0.00000	0.00000
2	OBRA(TH)220	1.03491	-1.65877	-0.00003	0.00028	58.20000	40.00000
3	OBRA A 15.75	1.01000	5.95954	398.00000	137.66420	0.09000	0.00000
4	OBRA'A'420	0.98579	1.35100	0.00001	-0.00005	0.00000	0.00000
5	PANKI 11	1.01000	-0.34776	24.00000	17.25541	0.00000	0.00000
6	PANKI 132	0.96523	-4.22968	0.00000	0.00056	80.00000	60.00000
7	PANKI(EXT)11	1.02000	3.83493	140.00000	57.56645	0.00000	0.00000
8	PANKI 220	0.98502	-2.54208	0.00003	0.00024	55.00000	34.50000
9	PANKI 400	0.97271	-1.37872	0.00000	-0.00015	0.00000	0.00000
10	HDJ'A' 11	0.95982	-3.23760	22.00000	6.90086	0.00000	0.00000
11	HDJ 132	1.00352	-5.05613	-0.00000	0.00107	110.00000	90.00000
12	HDJ'B' 11	0.98000	-2.00528	50.00000	39.36849	0.00000	0.00000
13	HDJ 220	1.01467	-3.43548	-0.00002	-0.00012	0.00000	0.00000
14	RIHAND 11	0.97000	-3.26373	40.00000	28.25042	0.00000	0.00000
15	RIHAND 132	1.01482	-4.01606	-0.00004	0.00011	73.00000	58.00000
16	OBRA(H) 11	0.96869	-3.68541	0.00000	0.00000	0.00000	0.00000
17	OBRA(H)132	1.02236	-3.68541	0.00004	0.00023	18.00000	10.50000
18	KHATIMA 11	1.05000	0.51414	25.00000	12.46170	0.00000	0.00000
19	KHATIMA132	1.01844	-3.30793	0.00000	0.00059	9.60000	8.00000
20	CHILLA 11	1.05000	10.09414	131.00000	60.04496	0.00000	0.00000
21	CHILLA 132	1.07562	5.98687	-0.00003	-0.00364	0.00000	0.00000
22	RAMGANGA 11	1.02000	2.22662	48.00000	14.45755	0.00000	0.00000
23	RAMGANGA132	1.06894	0.42576	-0.00001	0.00053	2.50000	1.20000
24	CHIBRO 11	1.04000	12.46404	120.00000	-6.78747	0.00000	0.00000
25	CHIBRO 220	1.05178	6.53243	0.00006	-0.00213	0.00000	0.00000
26	DAKRANI 11	1.05000	18.87955	33.00000	1.10543	0.00000	0.00000
27	DAKRANI 132	1.05649	10.32559	0.00002	-0.00532	2.50000	1.00000
28	DHALIPUR 11	1.05985	18.35905	51.00000	3.74078	0.00000	0.00000
29	DHALIPUR132	1.05914	10.52528	-0.00007	-0.00838	2.50000	1.00000
30	KULHAL 11	1.05000	23.15570	79.99999	4.96951	0.00000	0.00000
31	KULHAL 132	1.06072	10.71162	-0.00010	-0.01512	2.50000	1.00000
32	RODGANG 132	1.01560	-4.55651	-0.00003	-0.00002	18.00000	13.50000
33	SAHUPURI132	1.00781	-6.23139	0.00001	0.00007	50.00000	42.00000
34	SAHUPURI 220	1.02000	-4.06952	0.00001	12.64091	0.00000	0.00000
35	GAJIPUR 132	1.01663	-7.41904	0.00000	0.00004	12.00000	7.20000
36	MAU 132	1.03378	-7.76921	0.00000	-0.00003	13.20000	10.00000
37	GKP 132	1.03327	-8.83929	0.00001	0.00014	37.00000	35.00000
38	GKP 220	1.03237	-7.85072	0.00000	0.00001	0.00000	0.00000

39	0.00000						
25	CHIBRO 220	1.05178	6.53243	0.00006	-0.00213	0.00000	0.00000
26	DAKRANI 11	1.05000	18.87955	33.00000	1.10543	0.00000	0.00000
27	DAKRANI 132	1.05649	10.32559	0.00002	-0.00532	2.60000	1.00000
28	DHALIPUR 11	1.05985	18.35905	51.00000	3.74078	0.00000	0.00000
29	DHALIPUR132	1.05914	10.52528	-0.00007	-0.00838	2.50000	1.00000
30	KULHAL 11	1.05000	23.15570	79.99999	4.96951	0.00000	0.00000
31	KULHAL 132	1.06072	10.71162	-0.00010	-0.01512	2.50000	1.00000
32	ROBGANG 132	1.01560	-4.55651	-0.00003	-0.00002	18.00000	13.50000
33	SAHUPURI132	1.00781	-5.23139	0.00001	0.00007	50.00000	42.00000
34	SAHUPURI 220	1.02000	-4.06952	0.00001	12.64091	0.00000	0.00000
35	GAJIPUR 132	1.01663	-7.41904	0.00000	0.00004	12.00000	7.20000
36	MAU 132	1.03378	-7.76921	0.00000	-0.00003	13.20000	10.00000
37	GKP 132	1.03327	-8.83929	0.00001	0.00014	32.00000	35.00000
38	GKP 220	1.03237	-7.85072	0.00000	0.00001	0.00000	0.00000
39	KHALBAD 132	1.02283	-9.66607	0.00001	0.00003	9.60000	6.00000
40	BASTI 62	1.02031	-10.00920	0.00001	0.00004	9.60000	6.00000
41	FZD 132	1.00797	-8.75196	-0.00000	0.00007	16.00000	16.00000
42	NANDADIH132	0.94747	-8.56428	0.00001	0.00003	22.00000	20.00000
43	JAUNPUR 152	0.91694	-9.91312	-0.00001	0.00002	15.00000	12.00000
44	MIRZAPUR152	1.00507	-5.54804	0.00001	-0.00002	8.00000	5.00000
45	JIGNA 132	1.00206	-5.68727	0.00000	0.00003	8.00000	6.00000
46	SLN 132	1.02000	-7.58870	-0.00001	28.37426	58.00000	50.58000
47	SLN 220	1.02923	-5.56508	0.00000	0.00000	0.00000	0.00000
48	SLN'A' 400	0.96954	-2.27964	-0.00000	-0.00043	0.00000	0.00000
49	ALLD 132	1.04787	-3.68467	-0.00000	0.00013	34.00000	34.00000
50	ALLD 220	'.02014	-2.15370	0.00000	-0.00015	0.00000	0.00000
51	LUCKNOW132	0.95373	-4.76023	-0.00000	0.00037	50.00000	31.00000
52	LUCKNOW220	0.96407	-3.13441	-0.00001	-0.00034	0.00000	0.00000
53	LUCKNOW400	0.97653	-2.63423	0.00000	-0.00003	0.00000	0.00000
54	SITAPUR182	0.95741	-5.32063	-0.00000	0.00035	28.00000	18.00000
55	SITAPUR220	0.96193	-4.11007	0.00001	-0.00014	0.00000	0.00000
56	SHAJPUR132	0.98232	-5.08892	-0.00000	0.00060	22.00000	13.50000
57	SHAHPUR220	0.98232	-5.08892	0.00000	0.00000	0.00000	0.00000
58	DHONA 132	1.00632	-3.95914	-0.00001	0.00068	32.00000	31.00000
59	KHURJA 132	1.02437	-4.57611	0.00002	0.00018	20.00000	17.00000
60	KHURJA 220	1.01213	-3.09183	0.00002	-0.00029	0.00000	0.00000
61	BHOOR 132	1.02308	-4.30306	-0.00003	-0.00002	0.00000	25.00000
62	MURAD 132	1.05000	-4.20543	0.00000	29.03238	60.00000	48.00000
63	MURAD 220	1.00954	-2.27503	0.00000	-0.00270	0.00000	0.00000
64	MURAD 400	0.97946	-2.08277	-0.00000	0.00009	0.00000	0.00000
65	MEERUT132	0.99721	-2.55182	0.00000	-0.00017	40.00000	40.00000
66	MEERUT220	1.01132	-1.49732	0.00001	-0.00087	0.00000	0.00000
67	SHAMLI220	1.03252	1.08084	-0.00000	-0.00450	0.00000	0.00000
68	SAHAPUR132	1.07885	3.61730	-0.00001	-0.00123	18.00000	18.00000

69	SAHAPUR220	1.09114	4.23738	-0.00001	-0.00591	0.00000	0.00000
70	ROURKEE 52	1.07174	3.68174	-0.00003	-0.00236	6.00000	5.00000
71	HARDWARI32	1.06832	5.27604	-0.00001	-0.00025	18.00000	16.00000
72	RISH 132	1.05715	6.16039	0.00004	-0.00775	22.00000	17.00000
73	RISH 220	1.05000	4.09626	0.00000	-17.74436	0.00000	0.00000
74	DDN 132	1.05482	8.12917	-0.00000	-0.01355	13.00000	10.00000
75	KHODRI 132	1.05394	9.94136	-0.00001	-0.00501	2.60000	1.00000
76	KHODRI 220	1.05172	6.46886	0.00001	-0.01600	0.00000	0.00000
77	NEHTAUR132	1.05508	0.26898	0.00001	-0.00434	20.00000	24.00000
78	KASHPUR132	1.05818	-0.48697	0.00003	0.00030	5.00000	3.00000
79	MBD 132	1.04126	-1.92796	0.00000	0.00017	36.00000	36.00000
80	MBD 220	1.00456	-2.40857	-0.00000	0.00031	0.00000	0.00000
81	GAJRALA 72	1.00337	-3.10198	0.00001	0.00010	9.00000	7.00000
82	HAPUR 132	0.97461	-3.87003	-0.00001	0.00031	18.00000	18.00000
83	SHAGANJ132	0.91127	-10.17230	-0.00000	0.00002	5.00000	4.00000
84	HALDWANI132	1.04824	-0.92399	-0.00000	0.00018	8.00000	6.00000
85	MAINPURI220	1.01000	-4.05051	0.00000	45.54347	55.00000	48.00000
86	MUZAFFR220	1.03005	0.46595	0.00001	-0.00149	0.00000	0.00000
87	MUZAFFR132	1.03387	-0.14671	0.00000	-0.00049	32.00000	30.00000
88	AZAM220	1.00598	-5.53140	0.00001	0.00000	0.00000	0.00000
89	AZAM132	0.98996	-7.36138	0.00001	0.00002	10.00000	7.50000
90	SHAMLI132	1.03725	0.43283	-0.00001	-0.00056	15.00000	12.00000
91	OBRA'B'15.75	0.98862	-1.65877	0.00000	0.00000	0.00000	0.00000
92	OBRA'B'420	0.98862	-1.65877	0.00000	-0.00005	0.00000	0.00000
93	SLN'B' 400	0.96729	-5.56508	0.00000	-0.00002	0.00000	0.00000
94	OBRA'A' 33	1.01041	-0.31244	0.00000	0.00002	0.00000	0.00000
95	OBRA'B' 33	1.01206	-1.65877	0.00000	0.00001	0.00000	0.00000
96	SLN 'A' 33	1.00144	-4.10683	0.00000	-0.00001	0.00000	0.00000
97	SLN 'B' 33	1.00082	-5.56508	0.00000	-0.00001	0.00000	0.00000
98	PANKI 33	0.97932	-2.01212	0.00000	-0.00002	0.00000	0.00000
99	LKO 33	0.96978	-2.90340	0.00000	0.00000	0.00000	0.00000
100	MURAD 33	0.99574	-2.18829	-0.00000	0.00002	0.00000	0.00000

TOTAL GENERATION = 1291.394500 573.353480 TOTAL LOAD = 1263.700000 1054.480000 TOTAL LOSSES = 27.694458 -481.126530

LIST OF OUTPUT RESULTS

DMAX = 0.00048400 EPSIL = 0.00100000

DECOUPLED ITERATIVE TECHNIQUE CONVERGED IN 9 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1	OBRA(TH)10.5	1.00000	0.00000	129.47353	103.57990	0.00000	0.00000
2	OBRA(TH)220	1.03192	-1.65977	0.00256	0.01113	58.20000	40.00000
3	OBRA A 15.75	1.01000	5.95762	398.00002	137.56643	0.00000	0.00000
4	OBRA'A'420	0.98581	1.34917	0.00014	0.00150	0.00000	0.00000
5	PANKI 11	1.01000	-0.35102	23.99999	17.23487	0.00000	0.00000
6	PANKI 132	0.96529	-4.23271	0.00004	0.00011	80.00000	60.00000
7	PANKI(EXT)11	1.02000	3.83127	139.99996	52.48405	0.00000	0.00000
8	PANKI 220	0.98508	-2.54532	-0.00004	0.00069	55.00000	34.50000
9	PANKI 400	0.97280	-1.38258	-0.00007	-0.00064	0.00000	0.00000
10	HDJ'A' 11	0.96500	-3.26352	21.99997	9.69376	0.00000	0.00000
11	HDJ 132	1.00501	-5.06962	-0.00022	-0.00028	110.00000	90.00000
12	HDJ'B' 11	0.98000	-2.02024	49.99994	3[illegible].18531	0.00000	0.00000
13	HDJ 220	1.01527	-3.44960	0.00003	-0.00065	0.00000	0.00000
14	RIHAND 11	0.97000	-3.26482	39.99997	28.22650	0.00000	0.00000
15	RIHAND 132	1.01443	-4.01714	-0.00229	0.04130	73.00000	58.00000
16	OBRA(H) 11	0.96869	-3.68634	0.00000	0.00000	0.00000	0.00000
17	OBRA(H)132	1.02236	-3.68634	0.00483	-0.04472	18.00000	10.50000
18	KHATIMA 11	1.05000	0.50441	25.00003	12.10095	0.00000	0.00000
19	KHATIMA132	1.01937	-3.31919	0.00483	-0.00855	9.60000	8.00000
20	CHILLA 11	1.05000	10.07736	131.00021	59.98355	0.00000	0.00000
21	CHILLA 132	1.07566	5.97021	0.02153	-0.02100	0.00000	0.00000
22	RAMGANGA 11	1.02500	2.13775	47.99992	17.62359	0.00000	0.00000
23	RAMGANGA132	1.07006	0.35090	0.01158	-0.02347	2.50000	1.20000
24	CHIBRO 11	1.04000	12.46405	119.99994	-6.45591	0.00000	0.00000
25	CHIBRO 220	1.05148	6.53075	0.00034	-0.00020	0.00000	0.00000
26	DAKRANI 11	1.05000	18.91734	32.99995	1.51915	0.00000	0.00000
27	DAKRANI 132	1.05454	10.34747	0.00216	-0.00367	2.50000	1.00000
28	DHALIPUR 11	1.04500	18.51562	50.99990	-0.63088	0.00000	0.00000
29	DHALIPUR132	1.05700	10.55365	-0.00319	-0.00088	2.50000	1.00000
30	KULHAL 11	1.05000	23.20564	79.99994	5.67775	0.00000	0.00000
31	KULHAL 132	1.05875	10.73796	0.00787	-0.02005	2.50000	1.00000
32	ROBGANG 132	1.01561	-4.55755	-0.00129	0.01060	18.00000	13.50000
33	SAHUPURI132	1.00781	-6.23233	-0.00710	0.00307	50.00000	42.00000
34	SAHUPURI 220	1.02000	-4.07043	-0.00249	12.59835	0.00000	0.00000
35	GAJIPUR 132	1.01664	-7.41959	0.00027	-0.00220	12.00000	7.20000
36	MAU 132	1.03379	-7.76952	0.04840	-0.01423	13.20000	10.00000
37	GKP 132	1.03327	-8.84059	-0.01051	-0.01038	32.00000	35.00000
38	GKP 220	1.03237	-7.85210	0.00041	-0.00406	0.00000	0.00000

39	KHALBAD 132	1.02282	-9.66750	-0.00263	-0.00016	9.60000	6.00000
40	BASTI 62	1.02031	-10.01065	-0.00062	-0.00072	9.60000	6.00000
41	FZD 132	1.00798	-8.75360	0.00298	0.00333	16.00000	16.00000
42	MANDADIH132	0.94746	-8.56541	-0.00725	-0.00043	22.00000	20.00000
43	JAUNPUR 152	0.91692	-9.91389	0.00132	-0.00546	15.00000	12.00000
44	MIRZAPUR152	1.00507	-5.54911	0.00113	-0.00126	8.00000	5.00000
45	JIGNA 132	1.00206	-5.68839	-0.00231	-0.00001	8.00000	6.00000
46	SLN 132	1.02000	-7.59048	-0.00304	28.33423	58.00000	50.58000
47	SLN 220	1.02925	-5.56689	-0.00028	0.00307	0.00000	0.00000
48	SLN'A' 400	0.96958	-2.28173	-0.00012	-0.00186	0.00000	0.00000
49	ALLD 132	1.04789	-3.68617	0.00007	0.00003	34.00000	34.00000
50	ALLD 220	1.02015	-2.15526	-0.00246	-0.01596	0.00000	0.00000
51	LUCKNOW132	0.95390	-4.76169	-0.00001	0.00019	50.00000	31.00000
52	LUCKNOW220	0.96^19	-3.13728	0.00002	-0.00075	0.00000	0.00000
53	LUCKNOW400	0.97659	-2.63674	0.00000	0.00023	0.00000	0.00000
54	SITAPUR182	0.95782	-5.32308	0.00123	-0.00170	28.00000	18.00000
55	SITAPUR220	0.96218	-4.11380	0.00005	-0.00011	0.00000	0.00000
56	SHAJPUR132	0.98333	-5.10015	0.00065	0.00104	22.00000	13.50000
57	SHAHPUR220	0.98333	-5.10015	0.00000	0.00000	0.00000	0.00000
58	DHONA 132	1.00755	-3.97625	-0.00620	0.00 78	32.00000	31.00000
59	KHURJA 132	1.02515	-4.58410	-0.00101	0.00203	20.00000	17.00000
60	KHURJA 220	1.01261	-3.10336	0.00040	0.00029	0.00000	0.00000
61	BHOOR 132	1.02366	-4.31008	0.00701	-0.00217	0.00000	25.00000
62	MURAD 132	1.05000	-4.20955	-0.00055	28.12147	60.00000	48.00000
63	MURAD 220	1.00979	-2.28278	0.00051	-0.00039	0.00000	0.00000
64	MURAD 400	0.97967	-2.08982	0.00001	0.00041	0.00000	0.00000
65	MEERUT132	0.99741	-2.55928	0.00000	-0.00001	40.00000	40.00000
66	MEERUT220	1.01152	-1.50518	-0.00003	-0.00005	0.00000	0.00000
67	SHAMLI220	1.03260	1.07258	0.00012	-0.00054	0.00000	0.00000
68	SAHAPUR132	1.07910	3.60479	0.00359	-0.00474	18.00000	18.00000
69	SAHAPUR220	1.04109	4.22940	-0.00079	0.00002	0.00000	0.00000
70	ROURKEE 52	1.07215	3.66214	-0.00186	0.01344	5.00000	5.00000
71	HARDWAR132	1.06840	5.25928	-0.01104	0.01612	18.00000	16.00000
72	RISH 132	1.05686	6.14898	-0.00311	-0.01062	22.00000	17.00000
73	RISH 220	1.05000	4.08829	0.00037	-17.15502	0.00000	0.00000
74	DDN 132	1.05368	8.13333	-0.01036	0.02423	13.00000	10.00000
75	KHODRI 132	1.05124	9.95706	-0.00093	0.01333	2.50000	1.00000
76	KHODRI 220	1.05147	6.46718	0.00002	0.00048	0.00000	0.00000
77	NEHTAUR132	1.05680	0.22740	-0.01662	0.02473	20.00000	24.00000
78	KASHPUR132	1.05094	-0.54850	-0.00235	0.01061	5.00000	3.00000
79	MBD 132	1.04295	-1.95995	0.01112	-0.01201	36.00000	36.00000
80	MBD 220	1.00582	-2.43662	-0.00115	0.00070	0.00000	0.00000
81	GAJRALA 72	1.00515	-3.13075	-0.00481	0.00211	9.00000	7.00000
82	HAPUR 132	0.97641	-3.99629	-0.00123	-0.00023	18.00000	18.00000
83	SHAGARJ132	0.91124	-10.17300	0.00054	-0.00183	5.00000	4.00000

[illegible]	[illegible]	[illegible]	-[illegible]357	-0,[illegible]149	5,[illegible]76	4,00000	6,00000
	[illegible]	[illegible]	-[illegible],05575	0,[illegible]67	44,21151	5[illegible],00000	43,00000
[illegible]	[illegible]	1,03[illegible]	[illegible]	0,[illegible]12	-0,[illegible]010	0,00000	0,00000
[illegible]	[illegible]	[illegible]	-[illegible]	[illegible]	-[illegible],00021	32,[illegible]	1[illegible],00000
[illegible]	[illegible]	[illegible]	-[illegible]	[illegible]	3,[illegible]	[illegible]	[illegible],00000
[illegible]	[illegible]	[illegible]	-7,36[illegible]	-[illegible]	[illegible]	1[illegible],00000	[illegible],50000
[illegible]	[illegible]	[illegible]	[illegible]	-[illegible]27	[illegible]	15,00000	12,[illegible]00
[illegible]	[illegible]15,7[illegible]	[illegible]	-1,[illegible]77	[illegible]	3,[illegible]	0,00000	[illegible],00000
[illegible]	[illegible]	[illegible]	-1,[illegible]77	[illegible]	-0,[illegible]	0,00000	[illegible],00000
[illegible]	[illegible]	[illegible]	-[illegible]	[illegible]	-0,[illegible]	0,00000	[illegible],00000
94	[illegible] 33	1,01[illegible]	-[illegible]	0,[illegible]	0,[illegible]2	0,00000	0,00000
95	[illegible] 33	1,01207	-1,[illegible]77	0,[illegible]	[illegible],00	0,00000	0,00000
96	[illegible] 33	1,00147	-4,1[illegible]	0,[illegible]	0,00001	0,00000	0,00000
97	[illegible] 33	1,0[illegible]	-[illegible]	0,[illegible]	-0,00001	0,00000	0,00000
98	[illegible] 33	0,97940	-2,[illegible]	-0,[illegible]	0,00000	0,00000	0,00000
99	[illegible] 33	0,96[illegible]	-2,9[illegible]11	0,[illegible]05	0,00000	0,00000	0,00000
100	[illegible]HAD 33	0,99547	-2,19[illegible]	-,00000	-0,00001	0,00000	0,00000

TOTAL GENERATION = 1291,476209 572,937730 TOTAL LOAD = 1263,700000 1054,480000 TOTAL LOSSES = 27,776245 -481,542280

LIST OF OUTPUT RESULTS

DMAX = 0.00028205 EPSIL = 0.00100000

FAST DECOUPLED ITERATIVE TECHNIQUE CONVERGED IN 7 ITERATIONS

BUS	BUS NAME	VOLTAGE	ANGLE	GENERATION		LOAD	
1	OBRA(TH)10.5	1.00000	0.00000	129.34065	87.37264		
2	OBRA(TH)220	1.03566	-1.65207	0.00066	-0.00512	0.00000	0.00000
3	OBRA A 15.75	1.01000	5.95393	398.00004	129.94623	58.20000	40.00000
4	OBRA'A'420	0.98732	1.35254	0.00001	-0.00056	0.00000	0.00000
5	PANKI 11	1.01000	-0.31665	24.00000	16.92489	0.00000	0.00000
6	PANKI 132	0.96613	-4.19495	0.00001	0.00002	0.00000	0.00000
7	PANKI(EXT)11	1.02000	3.85967	139.99999	51.24441	80.00000	60.00000
8	PANKI 220	0.98604	-2.51068	0.00008	0.00008	0.00000	0.00000
9	PANKI 400	0.97384	-1.35406	-0.00004	0.00028	55.00000	34.50000
10	HDJ'A' 11	0.98000	-3.26549	22.00001	18.26205	0.00000	0.00000
11	HDJ 132	1.00889	-5.03709	-0.00012	0.00033	0.00000	0.00000
12	HDJ'B' 11	0.98000	-1.98950	50.00003	35.88148	110.00000	90.00000
13	HDJ 220	1.01644	-3.41721	-0.00045	0.00046	0.00000	0.00000
14	RIHAND 11	0.98000	-3.28414	39.99999	35.58976	0.00000	0.00000
15	RIHAND 132	1.02265	-4.02280	-0.00073	0.00148	0.00000	0.00000
16	OBRA(H) 11	0.97504	-3.66167	0.00000	0.00000	73.00000	58.00000
17	OBRA(H)132	1.02906	-3.66167	-0.00109	0.00232	0.00000	0.00000
18	KHATIMA 11	1.05000	0.54799	24.99999	12.28831	18.00000	10.50000
19	KHATIMA132	1.01986	-3.27752	-0.00116	0.00282	0.00000	0.00000
20	CHILLA 11	1.05000	10.13141	130.99904	60.84149	9.60000	8.00000
21	CHILLA 132	1.07515	6.02237	-0.01547	0.03032	0.00000	0.00000
22	RAMGANGA 11	1.02000	7.25367	47.99966	14.24049	0.00000	0.00000
23	RAMGANGA132	1.06707	0.45307	-0.01254	0.02501	0.00000	0.00000
24	CHIBRO 11	1.04000	17.51854	120.00028	-6.21194	2.50000	1.20000
25	CHIBRO 220	1.03126	6.58398	-0.00019	0.00001	0.00000	0.00000
26	DAKRANI 11	1.05000	18.98558	33.00006	1.69887	0.00000	0.00000
27	DAKRANI 132	1.05375	10.40876	-0.00158	0.00295	0.00000	0.00000
28	DHALIPUR 11	1.04000	18.62479	50.99996	-7.00517	2.50000	1.00000
29	DHALIPUR132	1.05608	10.61727	-0.00312	0.00623	0.00000	0.00000
30	KULHAL 11	1.05000	23.27892	79.99978	5.98804	2.50000	1.00000
31	KULHAL 132	1.05738	10.80087	-0.01157	0.02114	0.00000	0.00000
32	ROOGANG 132	1.02329	-4.54319	0.00198	-0.00413	2.50000	1.00000
33	SAHUPURI132	1.01724	-6.23327	-0.00077	0.00164	18.00000	13.50000
34	SAHUPURI 220	1.03000	-5.10900	0.00005	31.12472	50.00000	42.00000
35	GAJIPUR 132	1.02553	-7.10527	0.00019	-0.00042	0.00000	0.00000
36	MAU 132	1.04222	-7.74419	0.00236	-0.00437	12.00000	7.20000
37	GKP 132	1.03910	-8.77029	-0.00075	0.00161	13.20000	10.00000
38	GKP 220	1.03686	-7.80295	-0.00001	-0.00001	32.00000	35.00000

39	KHALBAD 132	1.02879	-9.58924	0.00031	-0.00062	9.60000	6.00000
40	BASTI 62	1.02634	-9.92934	0.00013	-0.00031	9.60000	6.00000
41	FZD 132	1.00797	-8.70082	0.00019	-0.00046	16.00000	16.00000
42	MANDADIH132	0.95787	-8.52535	0.00006	-0.00021	22.00000	20.00000
43	JAUNPUR 152	0.92780	-9.84616	-0.00003	0.00008	15.00000	12.00000
44	MIRZAPUR152	1.01300	-5.52305	0.00010	-0.00021	8.00000	5.00000
45	JIGN 132	1.01002	-5.66037	0.00008	-0.00025	8.00000	6.00000
46	SLN 132	1.02000	-7.53758	-0.00020	25.44135	58.00000	50.58000
47	SLN 220	1.03067	-5.51678	0.00004	0.00015	0.00000	0.00000
48	SLN'A' 400	0.97092	-2.25303	-0.00005	0.00013	0.00000	0.00000
49	ALLD 132	1.05134	-3.65602	0.00005	-0.00010	34.00000	34.00000
50	ALLD 220	1.02332	-2.13485	-0.00205	0.00449	0.00000	0.00000
51	LUCKNOW132	0.95483	-4.72660	-0.00007	-0.00009	50.00000	31.00000
52	LUCKNOW220	0.96517	-3.10361	-0.00002	-0.00016	0.00000	0.00000
53	LUCKNOW400	0.97781	-2.60556	0.00007	0.00014	0.00000	0.00000
54	SITAPUR132	0.95841	-5.28787	-0.00008	-0.00013	28.00000	18.00000
55	SITAPUR220	0.96299	-4.07812	0.00004	0.00021	0.00000	0.00000
56	SHAJPUR132	0.98302	-5.05891	-0.00007	0.00006	22.00000	13.50000
57	SHAHPUR220	0.98302	-5.05891	0.00000	0.00000	0.00000	0.00000
58	DHONA 132	1.00687	-3.93111	0.00031	-0.00107	32.00000	31.00000
59	KHURJA 132	1.02709	-4.53774	0.00042	-0.00089	20.00000	17.00000
60	KHURJA 220	1.01364	-3.06696	0.00001	-0.00015	0.00000	0.00000
61	BHOOR 132	1.02509	-4.26247	-0.00046	0.00098	0.00000	25.00000
62	MURAD 132	1.05000	-4.15709	0.00001	25.88926	60.00000	48.00000
63	MURAD 220	1.01040	-2.24012	-0.00023	-0.00058	0.00000	0.00000
64	MURAD 400	0.98037	-2.04981	0.00008	0.00034	0.00000	0.00000
65	MEERUT132	0.99789	-2.51399	-0.00004	0.00011	40.00000	40.00000
66	MEERUT220	1.01198	-1.46089	0.00005	-0.00017	0.00000	0.00000
67	SHAMLI220	1.03275	1.11942	-0.00019	-0.00017	0.00000	0.00000
68	SAHAPUR132	1.07858	3.65582	-0.00148	0.00104	18.00000	18.00000
69	SAHAPUR220	1.04068	4.28103	0.00075	-0.00084	0.00000	0.00000
70	ROORKEE 52	1.07145	3.71722	0.00435	-0.00774	6.00000	5.00000
71	HARDWAR132	1.06783	5.31234	0.00416	-0.00713	18.00000	16.00000
72	RISH 132	1.05635	6.20064	0.00653	-0.01423	22.00000	17.00000
73	RISH 220	1.05000	4.13785	-0.00094	-16.67737	0.00000	0.00000
74	DDN 132	1.05298	8.19017	0.00463	-0.00854	13.00000	10.00000
75	KHODRI 132	1.05046	10.31619	0.01128	-0.02362	2.50000	1.00000
76	KHODRI 220	1.05120	6.52041	0.00049	-0.00145	0.00000	0.00000
77	NEHTAUR132	1.05525	0.29574	0.00974	-0.01758	20.00000	24.00000
78	KASHPUR132	1.05842	-0.46089	0.00645	-0.01145	5.00000	3.00000
79	MBD 132	1.04175	-1.90515	0.00037	-0.00391	36.00000	36.00000
80	MBD 220	1.00548	-2.38455	0.00048	-0.00022	0.00000	0.00000
81	GAJRALA 72	1.00389	-3.07818	-0.00087	0.00137	9.00000	7.00000
82	HAPUR 132	0.97514	-3.84548	-0.00048	0.00120	18.00000	18.00000
83	SHAGANJ132	0.92222	-10.09983	-0.00000	0.00002	5.00000	4.00000

84	HALDWANI132	1.04-49	-0.89771	0.00004	-0.00018	8.00000	6.00000
85	MAINPURI220	1.01000	-4.00793	-0.00012	40.32485	55.00000	48.00000
86	MUZAFFR220	1.03042	0.50497	0.00026	-0.00044	0.00000	0.00000
87	MUZAFFR132	1.03422	-0.10848	-0.00037	0.00053	32.00000	30.00000
88	AZAM220	1.01530	-5.54313	-0.00030	0.00069	0.00000	0.00000
89	AZAM132	0.99840	-7.35082	-0.00228	0.00374	10.00000	7.50000
90	SHAMLI132	1.03752	0.47194	0.00026	-0.00032	15.00000	12.00000
91	OBRA'B'15.75	0.99222	-1.65207	0.00000	0.00000	0.00000	0.00000
92	OBRA'B'420	0.99222	-1.65207	0.00000	-0.00004	0.00000	0.00000
93	SLN'B' 400	0.96864	-5.51678	0.00000	-0.00004	0.00000	0.00000
94	OBRA'A' 33	1.01315	-0.30959	-0.00001	-0.00001	0.00000	0.00000
95	OBRA'B' 33	1.01573	-1.65207	0.00000	0.00001	0.00000	0.00000
96	SLN 'A' 33	1.00286	-4.06813	0.00000	0.00001	0.00000	0.00000
97	SLN 'B' 33	1.00222	-5.51678	0.00000	-0.00001	0.00000	0.00000
98	PANKI 33	0.98040	-1.98375	-0.00000	0.00000	0.00000	0.00000
99	LKO 33	0.97096	-2.87356	-0.00000	0.00000	0.00000	0.00000
100	MURAD 33	0.99663	-2.15425	0.00001	0.00000	0.00000	0.00000

TOTAL GENERATION = 1291.336500 568.158410 TOTAL LOAD = 1263.700000 1054.480000 TOTAL LOSSES = 27.636551 -486.321600